INELASTIC ANALYSIS OF FRAME STRUCTURES INCLUDING MEMBER AND JOINT SHEARS

BY

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NOMENCLATURE

a	undeformed shear panel length parallel to x axis
A	cross-sectional area
A_i	Area of i th subrectangle = A_j/n_j
A_j	Area of j th rectangle
A_s	effective shear area
AE	axial stiffness
b	width
b	undeformed shear panel length parallel to y axis
b_c	column flange width
$[B]$	incremental deformation-displacement matrix of order 3X6
c	damping coefficient
C_{sj}	shear area coefficient for j th rectangle
$[C_T]$	incremental damping matrix
d_b, d_c	distances between the centroids of beam and column flanges, respectively
d_g	girder depth
$[D]$	incremental internal force-deformation matrix of order 3X3
E	modulus of elasticity
$\bar{E}$	history dependent stiffness of a component curve
E_k	$\bar{E}$ for k th component
E_{sh}	strain hardening modulus
$\{E\}_j$	dynamic equilibrium error at j th time station
EI	flexural stiffness

f_x, f_y joint forces parallel to x and y axes, respectively

$\{f\}$ discrete elelment end-force vector of order 6

$\{f\}$ joint force vector

$\{f(t)\}$ nodal force vector

$\{F_D(t)\}$ damping force vector

$\{F_I(t)\}$ inertia force vector

$\{F_S(t)\}$ stiffness force vector

G modulus of rigidity

G_j modulus of rigidity of the j th rectangle

G_t slope of the joint shear stress-strain curve

h half length of undeformed discrete element

h height

h_ℓ, h_r horizontal distances of the left and right vertical edges of the rectangular shear panel from the centroid, respectively

H projection of the deformed discrete element shear model on the undeformed original direction

I second moment of area

I_f moment of inertia of the flange

J_2' second invariant of the deviatoric stress tensor

k shear area factor

k a constant

k_s spring stiffness

$[k]$ tangent stiffness matrix

$[k]_c$ conventional portion of discrete element stiffness matrix

$[k]_s$ initial stress portion of discrete element stiffness matrix

$[k]_{st}$, $[k]_{sv}$ portion of discrete element initial stress stiffness matrix due to axial and shear forces, respectively

$K(p)$ complete elliptic integral of the first kind

$[K]$,$[K_T]$ tangent stiffness matrix

l	span
l	number of linear line segments defining the symmetric part of a virgin stress-strain curve
l_j	number of component curves that constitute the virgin σ-ε curve for the material of j th rectangle
m	number of input rectangles for a cross-section
m_y, m_z	couples produced by the shear forces acting along the edges of the rectangular shear panel perpendicular to x and y axes, respectively
M	moment
M	internal moment contributed by j th rectangle
$[M]$	mass matrix
n	post-yield stiffness parameter
n_j	number of equal division of j th rectangle
P	mean normal stress
P	axial load or applied lateral load
P_{cr}	critical buckling load
P_E	Euler critical load
$\{P\}$	load vector
Q	first moment of area about the neutral axis ($A\bar{y}$)
R	radius of curvature
S_k	slope of line segment connecting points k and k-1 of the virgin stress-strain or force-deformation curve
t	equivalent thickness of the shear panel
t_{cf}	column flage thickness
t_{cw}	column web thickness
t_s	thickness of the shear reinforcement area parallel to the web
T	internal axial force
T_j	internal axial force due to j th rectangle
$[T]$	transformation matrix

u_x, u_y	x and y displacements of the panel, respectively
u_A	x displacement at point A
$\{u\}$	displacement vector
U	strain energy
v_b, v_t	vertical distances of the bottom and top horizontal edges of the rectangular shear panel from the centroid, respectively
v_A	y displacement at point A
V	shear force normal to the deformed axis
V_j	shear force on j th rectangle
w	displacement of member
w_f, w_n, w_s, w_t	deflection due to flexural, normal, shear, and total stresses, respectively
$\{w\}$	discrete element end-displacement vector of order 6
$\{w\}$	4 DOF displacement vector for a joint
$\{\bar{w}\}$	3 DOF displacement vector a member end
$\{W\}$	joint displacement vector
y	difference between the displacements of member and member chord
y	distance of a point from the neutral axis in a section
$\bar{y}$	distance of the centroidal area from the neutral axis
y_i	height of i th subrectangle from the centroid of the section
Y_k	stress defining the k th component curve
α	damping constant related to mass matrix
α	stiffness degradation factor for a material
β	damping constant related to stiffness matrix
β	yield stress growth factor for mild steel
γ	a variable of α, β, and Δt
γ	shear strain
γ_m	maximum average shear deformation

γ_{xy}	shear strain
γ_y	yield shear strain
$\delta_a, \delta_m, \delta_s$	axial, flexural, and shear deformations
Δ	relative joint displacement
Δt	time increment
ε	flexural strain
ε_c	strain at the centroid of a section
ε_i	strain at the center of i th subrectangle
ε^p_{ij}	plastic strain on the plane i along the direction j
ε_k	strain defining the k th abscissae of virgin σ-ε curve
$\bar{\varepsilon}_p$	effective plastic strain
εr_k	residual strain of k th component curve
εrt_k	temporary value of the residual strain of k th component curve during iteration
ε_s	shear strain
$\{\varepsilon\}$	generalized strain vector for discrete element
θ	angle that line joining the ends of deformed discrete element makes with the undeformed element direction
θ_r	rigid body rotation
θ_s	shear deformation
θ_v, θ_z	rotations of y and x axes in a shear panel
θ_A	rotation at point A
ν	Poisson's ratio
ξ	time variable
$\Pi_{d\varepsilon^p}$	second invariant of the plastic strain increment tensor
σ	flexural stress
$\bar{\sigma}$	history dependent stress of a component curve at a general material point
$\bar{\sigma}$	effective stress

σ_i	stress at the center of i th subrectangle
σ_{ij}	stress on the plane i along j direction
σ'_{ij}	deviatoric stress on plane i along j direction
σ_k	k th ordinate of the virgin σ-ε curve
σ_y	uniaxial yield stress
σr_k	fictitious stress of the k th component curve at a material point
$\{\sigma\}$	generalized stress vector for discrete element
τ	shear stress
τ_{max}	maximum shear stress
τ_y	yield shear stress
ϕ	curvature
ψ_1, ψ_2	angles associated with the discrete element models
ω	circular frequency

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INELASTIC ANALYSIS OF FRAME STRUCTURES
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A computer program, FRAME82, is developed to perform inelastic static and dynamic analyses of plane frame structures including member and joint shear deformations. The effects of parameters such as inelastic material properties and member and joint supports, nonlinear geometry, cyclic loading, mass dependent viscous damping, etc., are also included in the program. FRAME82 utilizes a newly developed Discrete (Finite) Element Shear Model to incorporate the effects of member shear, in addition to the Discrete Element Flexural Model that considers only flexural and axial deformations. Joint shear panels are assumed to have only shear deformations, and flexural and axial deformations are ignored. Besides the three regular degrees of freedom, namely, horizontal, vertical, and rotational displacement, the program requires an additional rotational degree of freedom for each joint to include the joint shear deformation effects.

The structure stiffness is formulated from the stress-strain level and several inelastic models including Masing are incorporated. The program updates the structure stiffness after each iteration within each time step and adds any unbalance in "dynamic equilibrium" as a corrective load at the beginning of the subsequent iteration.

The program is verified with several simple structures that have either theoretical solutions or analytical results. The agreement is very good in most of the examples. The reliability of the discrete element shear model and the influence of the parameters that affect the structure response are studied. Several structures with experimental data are analyzed using FRAME82. The analysis of a three story frame tested at the University of California, Berkeley, indicates permanent deformations of the joint shear panels, which were not obtained in the DRAIN 2D analysis.

A user input guide with detailed descriptions is presented with several examples.

CHAPTER 1

INTRODUCTION

1.1 General

In the design of a structure, it is necessary to satisfy both serviceability requirements to avoid functional failure and safety requirements to assure safety against structural failure. The serviceability requirements impose the need to keep the response of the structure in the elastic range and to limit the displacement under moderate loading which may occur numerous times during the life of the structure. In case of an extreme loading, structural failure must be prevented. In order to satisfy the second requirement, the structure must have the ability to absorb and ultimately dissipate large amounts of energy. It is not economical to design a frame subjected to extreme loads occurring during earthquakes of exceptionally high intensity, extreme wave conditions or heavy wind storms that have low probabilities of occurrence to remain within the elastic or proportional limits.

The current concept of earthquake-resistant design involves the structure remaining elastic or nearly so under the influence of moderate earthquakes of frequent occurrences, and the structure yielding locally into the inelastic range, but with safety from collapse, even under the conditions of the most severe probable earthquake (5, 33). Each structural component of a moment resistant frame must be designed such that its ductility allows a redistribution of moments without failure of the component, until the maximum amount of earthquake energy input is

applied to the structure, to avoid structural failure under an extreme loading. Ultimately, all the energy must be dissipated by internal friction and inelastic deformation in both the structural and non-structural elements.

Due to the advent of Finite Element Method techniques and computers and the need of the detailed understanding of the behavior of earthquake-resistant structures, nonlinear analysis of structures has attracted much attention during the past three decades (1-56). Nonlinear analysis includes primarily the effects of material and geometric nonlinearities (22). Material nonlinearity includes nonlinear stress-strain curve for frame materials and supports with a nonlinear reaction-displacement curve due to nonlinear soil response. The nonlinear response is significant in most materials even when the loading is monotonic. Load reversals and cyclic loading greatly increase the nonlinear effects on frames with inelastic materials. Geometric nonlinearity arises from the consideration that points of application of the loads of a system are displaced due to large deformations, and the analysis can no longer be based on undeformed geometry. The axial forces on frame members cause secondary moments. The secondary moment can be divided into two components, P-Δ moment and P-y moment. The P-Δ moment is equal to the axial force P times the joint displacement Δ. The P-y moment is equal to the force P times the distance y, where y is the difference between the displacement of the member and displacement of the member chord.

1.2 Available Procedures for Nonlinear Inelastic Analysis of Frames

Early attempts to model the inelastic response of structures subjected to earthquake motion appeared in the form of an elasto-plastic

approximation to the inelastic behavior of the structure. An elasto-plastic model was utilized by Berg (2), Newmark (39), and Penzien (41) in the late 1950's to analyze single story frames and by Hanson and Fan (19) in the late 1960's to analyze multistory buildings. This model, coupled with the numerical integration of the dynamic equations of motion, afforded the first detailed insight into the inelastic characteristics of buildings during earthquake excitation.

A bilinear model was utilized by Iwan (26) to study inelastic member behavior in 1961 for simple yielding structures and by Clough, Benuska, and Wilson (9), Giberson (16), and Grant (18) in later years. Jennings (27) in 1963 utilized a curvilinear approximation for simple yielding structures and in 1967 Kaldjian and Fan (29) utilized Ramberg-Osgood approximation to the inelastic behavior of structural elements in simple structures subjected to earthquake excitation. Goel (17) expanded the Ramberg-Osgood model to multistory structures by making use of the symmetrical nature of the response of a multistory single bay frame.

Workman (55) developed a program to analyze the dynamic response of a multistory single bay braced frame in 1969. The frame is considered to have three distinct structural elements. They are Diagonal Cross Braces, Girders, and Columns. The diagonal braces are tension carrying members with elasto-plastic behavior. Girders are ideal elasto-plastic beams and axial deformations are neglected. Columns are elasto-plastic beam-columns with axial force effects accounted in the stiffness, deflection pattern and plastic moment characteristics of columns. The moment-curvature relation is nonlinear in the plastic range due to the modification of the plastic moment by the axial force. Nonlinear

response of the frame is obtained by a numerical procedure. The structure is assumed to respond linearly during each time increment. However, member properties may be changed from one interval to the next. Thus, the nonlinear response is obtained as a sequence of linear responses of successively differing systems.

Latona (36) studied the significance of geometric and material nonlinearities in static and dynamic analyses. His analysis included partial plastification of a cross-section, spread of plastification along the length of a member, inelastic strain reversals and P-Δ frame moments. He divided a cross-section into a finite number of layers. Each layer is assumed to have constant stress as of its centroid. He utilized an ideal elasto-plastic stress-strain relationship to represent the behavior of the material. The member stiffness matrices are obtained by integrating over each cross-section to obtain the section flexibility coefficients, integrating over the length of the member to obtain the member flexibility matrix, and inverting the flexibility matrix. Between time increments, geometry of the structure is updated by adding the displacements that occurred during the preceeding increment to the joint coordinates at the beginning of that increment; i.e., P-Δ moment is included, but P-y moment is not considered.

Workman and Latona considered only lateral modes of vibration and reduced the unknown displacements to one-third the original number by assuming negligible inertia loads corresponding to vertical and rotary displacements and considering the static equation. They further utilized kinematic condensation which simply imposes the condition that all joints at a given floor level displace laterally by the same displacement; i.e., one degree of freedom per story is retained explicitly.

Hays and Matlock (23) developed FRAME53 to analyze statically loaded plane frames using a Discrete Element Model. This analysis takes into account the actual stress-strain behavior of the materials of which the frame is made. It also handles geometric nonlinearities and nonlinear soil support characteristics. Even though the material and support characteristics are specified as nonlinear, they are elastic in behavior. The discrete element model is shown in Fig. 1.1 (22). It consists of two rigid end bars which are rigidly connected to the neighboring elements to preserve vertical, horizontal, and rotational compatibility at the nodal points, a middle bar that is rigid in bending but extensible, and two rotational springs at the hinges.

A member is divided into a finite number of elements and thus allows member properties, loading, and support conditions to vary along its length. The individual members are solved separately to obtain each member's stiffness and fixed end force matrices. Since member and structure solutions are performed separately, an iterative cycle for each member occurs within the iteration of structural joint displacements. The P-Δ and P-y moments are taken care of in the analysis by virtue of the large displacement analysis of the element model.

Kanaan and Powell (30) also made the same assumptions as Workman (55) and Latona (36) on effective degrees of freedom and kinematic condensation. The frame is considered to have the following structural elements: (i) Truss bar (ii) Beam Column element (iii) Semi-rigid Connection element and (iv) Shear Panel element. All of the elements are assumed to have bilinear relationship between force and displacement. Yielding is restricted to specific locations. Inelastic

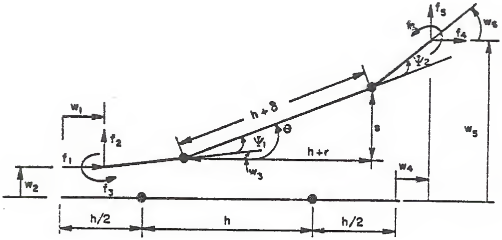


Figure 1.1 Discrete Element Flexural Model (22)

axial deformations are neglected in beam-column elements because of the difficulty of considering the interaction between axial and flexural deformations after yield. Infill panel elements are assumed to have shear stiffness only in the XY plane. The shear panel provides resistance through shear deformation to relative horizontal and/or vertical displacement of nodes it connects. Semi-rigid connection elements are used to account for the angle changes that occur between connected beams or columns. Damping is included in their analysis. It is assumed as a linear combination of mass and stiffness matrices. Only P-Δ moment is incorporated in the program to account for nonlinear geometry.

Santhanam (47) developed FRAME63 which is capable of inelastic static and dynamic analysis of plane frames including the effects of geometric and material nonlinearities in 1978. This program differs from the other available programs due to its capability of handling many types of stress-strain relationships. However, the virgin stress-strain curve is assumed to be symmetric in tension and compression. Several inelastic unloading models, including the Masing Model, were used to represent general piecewise linear symmetric inelastic stress-strain and force deformation curves are incorporated in their program.

A member is divided into a finite number of elements which are then divided into several layers. The same discrete element model which was used by Hays is used to form member stiffness matrix. Three degrees of freedom are considered for each node. Both P-Δ and P-y moments are included in the analysis. However, it does not include effects such as damping and deformations of panel zones, which are included in the program developed by Kanaan and Powell (30).

The programs developed by Santhanam (47) and Kanaan and Powell (30) are the two which handle more parameters which influence the inelastic response of a structure. Even though a more general stress-strain curve was used by Santhanam, effects of member and joint shears and damping are not considered. On the other hand, Kanaan and Powell accounted for damping, rigidity of joint and shear deformations due to panel zones, but they utilized a bilinear relationship between generalized force and generalized displacement. It is to be noted that Kanaan and Powell considered neither the inelastic axial deformations of columns nor P-y moments. Shear deformation was considered only in shear panels but not in beams.

1.3 Purpose of this Research

The purpose of this research is to develop a computer aided analysis that includes all the parameters such as general stress-strain curve for the material, P-Δ moment, P-y moment, member shear, joint shear, viscous damping, etc. The following are the objectives of this research.

(i) Develop a discrete element model to include the member shear in the frame analysis.

(ii) Develop a technique to include connection panel deformation in the response analysis of structures subjected to earthquake motions.

(iii) Incorporate the above two features with viscous damping into FRAME63 without disrupting the existing capabilities of the program to develop a new program, FRAME82.

(iv) Study the influence of each parameter on the behavior of the structure.

(v) Compare the predicted response with the available experimental data and analytical results.

1.4 Outline of Presentation

Chapter 2 reviews the elementary beam theory and focuses on the influence of shear on deflection and buckling load. A new discrete element model is developed in Chapter 3 to include the member shear. Chapter 4 is devoted to the derivation of cross-section behavior from the material nonlinear stress-strain curve. It is very similar to that discussed by Santhanam (47) but the incremental force deformation matrix is derived for the discrete element shear model. A technique to incorporate the joint deformation is discussed in Chapter 5. However, this method is restricted in its present application to the rectangular frames with no diagonal bracings. A numerical scheme is presented in Chapter 6 to solve the governing coupled frame equations. Even though mass and stiffness dependent damping are included in the presentation, only mass dependent damping is embodied in the program. The main aspects of the program FRAME82 are discussed in Chapter 7. In Chapter 8, analytical solutions of simple structures are compared with the results obtained from FRAME82. Comparison between the available experimental data and predicted behavior of these structures by FRAME82 is included in Chapter 9. Chapter 10 summarizes the scope of the present research and includes recommendations for further research.

Appendix A contains the required matrices to obtain tangent stiffness matrix for a discrete element. The constant average acceleration method is presented in Appendix B. An input guide with detailed explanations is given in Appendix C. Appendix D deals with the job control language statements and space requirements of the storage

devices. Appendices E, F, G, H, and I include a glossary of FORTRAN variables, FORTRAN listing of FRAME82, sample input, sample output, and digitized values of earthquake motions used in example problems.

CHAPTER 2

SHEAR CORRECTIONS TO CLASSICAL BEAM THEORY

2.1 General

The classical beam theory produces errors in both predicted stresses and strains. The error in stress can generally be ignored in the static loading of structure made of ductile materials, but consideration should be given if brittle materials or fatigue conditions are involved. The error in strain chiefly affects the deflections, underestimating deflections, while overestimating buckling loads and natural frequencies. These errors are generally negligible in slender beams under usual types of loading but are serious in short beams and beams under closely spaced loads which alternate in direction. This error in strain is also likely to be important in "sandwich" beams, latticed beams and flanged beams, where most of the material is concentrated in outer faces and inner part is lightened until it is just strong enough to resist transverse shear force. The resulting shear strain produces additional deflection which is of the same order of magnitude as of the flexural deflection that is given by the classical theory. This chapter deals with the improvements that could be made to the classical beam theory to obtain better estimates of deflection (14, 52).

2.2 Flexural Deformations

The classical beam theory, which incorporates several simplifying assumptions, predicts deflection only due to flexural deformations. The

fundamental assumptions are straight beam, homogeneous, isotropic and elastic material, plane sections remain plane during bending deformations, small deflections compared to the original length of the beam, and beam loaded in a plane containing one of the principal moment of inertia axes (49). The radius of curvature R of the axis of the beam, flexural stress σ at a distance y from the neutral surface, bending moment M, second moment of area I, and modulus of elasticity E are related by the following expression (25, 54):

$$\sigma/y = E/R = M/I \tag{2.1}$$

The curvature of the neutral axis given by

$$1/R = \pm d^2w/dx^2/[1+(dw/dx)^2]^{3/2} \tag{2.2}$$

is approximated by

$$1/R = \pm d^2w/dx^2 \tag{2.3}$$

where w is the deflection. Substituting Eq. 2.3 in Eq. 2.1 gives

$$d^2w/dx^2 = \pm M/EI \tag{2.4}$$

This expression is a force deformation relation for a beam subjected to pure bending. However, it represents a good approximation of the beam behavior when the deformations due to shear and axial loads are insignificant. The sign in Equation 2.4 has to be chosen such that it will be consistent with the choice of coordinate axes and the definition of positive direction for bending moment. Adoption of the sign conventions illustrated in Fig. 2.1 leads to

$$d^2w/dx^2 = M/EI \tag{2.5}$$

2.3 Shear Deformations

Since the present study deals with member shear effects extensively, a detailed derivation of force deformation relation for shear is presented in this section. The shear stress τ in a beam at any

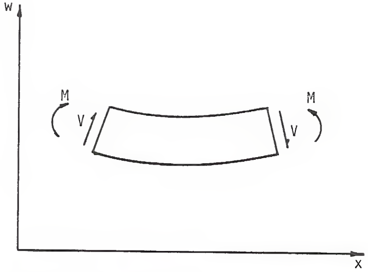


Figure 2.1 Coordinate System and Sign Convention for Bending Moment and Shear

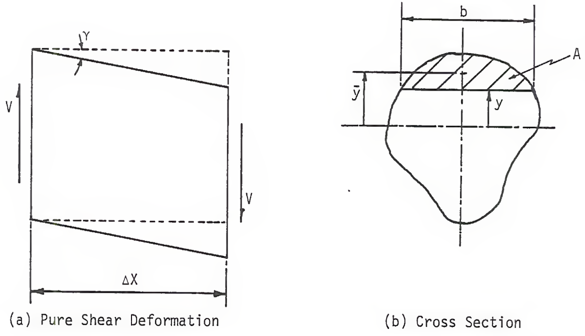


Figure 2.2 Deformation of a Beam Element due to Shear

transverse cross section in its length, and at a point a perpendicular distance y from the neutral axis, resulting from bending is given by

$$\tau = VA\bar{y}/Ib \text{ or } VQ/Ib \tag{2.6}$$

where V is the applied shear force; A is the area outside of the section parallel to the neutral axis at a distance y (shaded region in Fig. 2.2); $\bar{y}$ is the distance of the centroid of area A from the neutral axis; I is the second moment of area of the complete cross section; b is the breadth of the section at position y; and Q is equal to A times $\bar{y}$ (25).

A beam of finite length ΔX shown in Fig. 2.2 with its cross section is subjected to a shear force V. Castigliano's first theorem will be used to obtain the shear deflection under pure shear loading. The strain energy U of the beam element is

$$U = \iint (\tau^2/2G)dydz\Delta X \tag{2.7}$$

$$= (\Delta X/G)\iint((VQ)^2/2I^2b^2)dydz \tag{2.8}$$

Hence, the shear deflection δ_s is

$$\delta_s = -\partial U/\partial V = -(\Delta X/G)\iint(Q^2/I^2b^2)Vdydz$$

$$= -(\Delta XV/I^2G)\iint(Q^2/b^2)dydz = \gamma\Delta X \tag{2.9}$$

i.e. $$\gamma = -(V/I^2G)\iint(Q^2/b^2)dydz = -kV/A_sG \tag{2.10}$$

where $$k = (A_s/I^2)\iint(Q^2/b^2)dydz \tag{2.11}$$

in which A_s = effective shear area, k = shear area factor, and γ = change in the slope of middle surface due to shear deformations. A is equal to the total area for rectangular and circular sections and the web area for I-sections. The value of k, which is depended on the shape of the cross section, is 1.2 for rectangle, 1.11 for circle and nearly 1.0 for most of the I-sections (52, 53).

2.4 Approximate Analysis of Beam with Center Load

The material presented in this section is selected from the book by Donnell (14). The relative magnitudes of the deflections due to flexural, shear, and normal stresses are studied considering a simply supported beam of rectangular cross section with center load P, shown in Fig. 2.3.

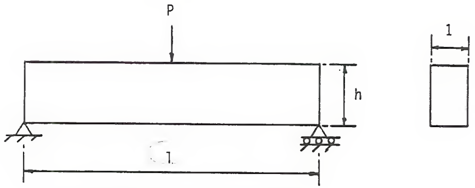
The flexural deflection w_f due to longitudinal bending stress is predicted by classical beam theory as

$$w_f = -P\ell^3/48EI = -P\ell^3/4Eh^3 \qquad (2.12)$$

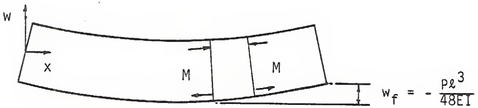
The shear deflection w_s caused by transverse shear strain is approximately calculated by assuming uniform shear stress distribution over the cross section (instead of the parabolic distribution with zero stress at the top and bottom fibers). This assumption requires the cross sections to remain plane and vertical. The shear strain ε_s = P/2hG is the angle between the cross sections and the top and bottom surfaces, where P/2 is the total shear force. Therefore,

$$w_s = -\varepsilon_s\ell/2 = -P\ell/4hG = -(1+\nu)P\ell/2hE \qquad (2.13)$$

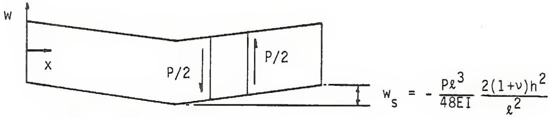
Normal strains which are developed by both transverse and longitudinal stresses produce negligible changes in the transverse length. However, an appreciable effect is produced by the longitudinal expansion, of the material directly under the load P due to Poisson's ratio effect. There is a similar expanion under the end reactions P/2 but it has a negligible effect on deflection. Assume that P is uniformly distributed over a small width Δ and the lateral compressive stress varies from P/Δ at the top to zero at the bottom. Due to Poisson's ratio effect the top will expand horizontally a distance (P/Δ) (ν/E) $(\Delta/2)$ = $\nu P/2E$ on each side of the center line and



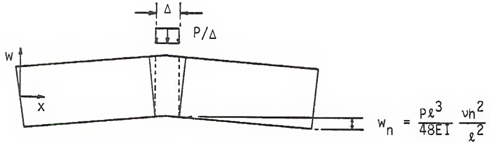
(a) Elevation and Cross Section



(b) Flexural Deflection w_f



(c) Shear Deflection w_s



(d) Deflection w_n due to Normal Stresses

Figure 2.3 Rough Analysis of a Beam with Center Load

the expansion linearly decreases to zero at the bottom. Therefore, the vertical side at the center will rotate through an angle of $(\nu P/2E)/h = \nu P/2hE$. Hence, the deflection w_n due to normal stresses is

$$w_n = (\nu P/2hE)\ell/2 = \nu P\ell/4hE \tag{2.14}$$

Assume that the total deflection can be obtained by adding the deflections that are derived considering each deformation independently. The deflections w_f, w_s, w_n and the total deflection w_t can be written in the form

$$w_f = -P\ell^3/4Eh^3$$

$$w_s = -(P\ell^3/4Eh^3)[2(1+\nu)h^2/\ell^2]$$

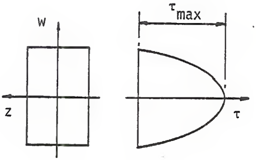
$$w_n = (P\ell^3/4Eh^3)\ (\nu h^2/\ell^2)$$

$$w_t = w_f + w_s + w_n = -(P\ell^3/4Eh^3)[1+(2+\nu)h^2/\ell^2] \tag{2.15}$$

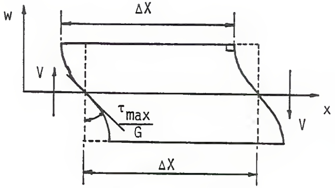
The second term in the bracket of w_t represents the correction to the classical elementary formula. It is to be noted that deflection due to transverse normal stress is proportional to and much smaller than that due to transverse shear strain. The former can therefore be taken into account by multiplying the deflection due to transverse shear by a numerical factor of the order of unity.

2.5 Combined Flexural and Shear Deformations

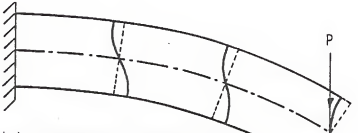
Timoshenko assumed that the deflection due to bending and shear can be determined by superposition (54). This could be justified by closely examining the effect of shear deformations on a beam. For a beam of rectangular cross section, Eq. 2.6 indicates a parabolic shear distribution as shown in Fig. 2.4 (a). Therefore, the shear strain $\gamma = \tau/G$ must vary in a similar fashion. This implies originally plane cross sections distort in the manner shown in Fig. 2.4 (b). Figure 2.4 (c) displays the deformed plane sections of a rectangular



(a) Shear Stress Distribution on a Rectangular Cross Section



(b) Elevation of the Warped Beam of Finite Length ΔX



(c) Rectangular Cantilevered Beam with Warped Cross Sections

Figure 2.4 Effect of Shear on Plane Cross Sections

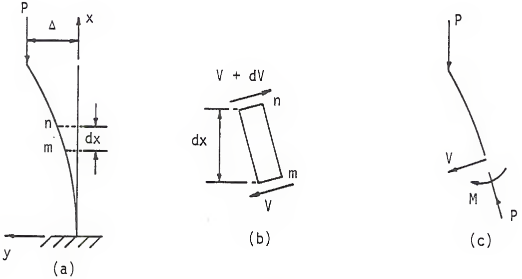


Figure 2.5 Cantilevered Column

cantilevered beam due to flexural and shear deformations. The shearing strains are zero at the upper and lower surfaces and equal to τ_{max}/G at the neutral surface. Hence, the deformed sections remain normal to the longitudinal fibers at the upper and lower surfaces and inclined to the neutral surface at an angle equal to the shear strain τ_{max}/G. The warping of all cross sections is the same as long as the shear force remains constant. Hence, shear stresses τ do not contribute to the longitudinal strains and the distribution of the longitudinal stresses σ is the same as in the case of pure bending. A more elaborate theoretical investigation reveals that the influence of shear deformations on flexural strains and stresses is very small, even when the shear force varies along the length of the beam (54). Hence, it is reasonable to add the deflections obtained in separate flexural and shear analyses to obtain the total deflection. Moreover, the effect of transverse normal stresses in the total deflection could be included in the analysis by properly modifying the shear area factor.

Using the principle of superposition,

$$w_t = w_f + w_s \tag{2.16}$$

Differentiating twice with respect to x gives

$$d^2w_t/dx^2 = d^2w_f/dx^2 + d^2w_s/dx^2 \tag{2.17}$$

From Equations 2.5 and 2.9

$$d^2w_f/dx^2 = M/EI$$

$$dw_s/dx = \gamma$$

Substituting the above relationships in Eq. 2.17 yields

$$d^2w_t/dx^2 = M/EI + d\gamma/dx$$

i.e. $$d^2w_t/dx^2 - d\gamma/dx = M/EI \tag{2.18}$$

Equation 2.18 is the general force deformation relationship that includes the effects of flexural and shear deformations for a beam.

2.6 The Effect of Shearing Force on the Buckling Load

Consider the column shown in Fig. 2.5 to derive an expression for buckling load including the shear effects. The shear force V and the moment M at any section can be obtained considering the equilibrium of the column above that section. Hence,

$$V = -Pdy/dx$$

$$M = P(\Delta - y)$$

Substituting the above expressions into Eq. 2.18 gives

$$d^2y/dx^2 - (d/dx)(-k/A_sG)(-Pdy/dx) = P(\Delta - y)/EI$$

For a prisimatic column of constant cross section the above equation becomes

$$(d^2y/dx^2)(1-kP/A_sG) = P(\Delta - y)/EI$$

i.e. $$d^2y/dx^2 = [P/EI(1-kP/A_sG)]\ (\Delta - y) \tag{2.19}$$

Solving the above differential equation for critical load would give

$$P/EI(1-kP/A_sG) = \pi^2/4L^2$$

from which

$$P_{cr} = P_E/(1+kP_E/A_sG) \tag{2.20}$$

where, $$P_E = \pi^2 EI/4L^2 \tag{2.21}$$

represents the Euler critical load for this case and L is the original length of the column. Thus, owing to the action of shearing forces, the critical load is diminished in the ratio

$$1/(1 + kP_E/A_sG)$$

In the case of solid columns this ratio differs but very little from unity. But in the case of built-up columns consisting of struts connected by lacing bars or batten plates, the ratio may vary a lot from

unity and the effect of shear deformations may become of practical importance. For more informationm refer to Theory of Elastic Stability by Timoshenko and Gere (53).

CHAPTER 3

DISCRETE ELEMENT SHEAR MODEL

3.0 Introduction

Discrete and Finite Element Methods are similar. Both methods require the structure to be divided into a finite number of elements, the behavior of which is specified by a finite number of parameters. The solution of the structure as an assembly of its elements follows precisely the same rules applicable to standard discrete problems (56). The basic difference between these two methods is that a continuous displacement function is used for each element in the Finite Element Method, and displacements are "lumped" at a finite number of points within an element in the Discrete Element Method. The points at which the displacements are lumped are referred to as hinges in this presentation. Division of members into a finite number of elements facilitates the handling of the geometric nonlinearity, i.e., P-Δ and P-y moments, and any variation in the member section properties, in the analysis. The hinges are convenient points for lumping the element deformations. Then nonlinear material force-deformation response can be monitored at these hinges. Discrete Element Flexural Model developed by Hays and Matlock (22) includes flexural and axial deformations, but shear deformations are ignored. The discrete element shear model that is developed in this chapter incorporates the effects of axial, flexural, and shear deformations of the members in the analysis.

3.1 Geometric Representation of the Discrete Element Shear Model

Figure 3.1 (a) displays the geometric representation of the discrete element shear model with the element end displacements and deformations. It consists of two rigid bars, which are rigidly connected to the adjacent elements to preserve horizontal, vertical, and rotational compatibility at the nodes. Each bar is of length h and the undeformed length of the element is 2h. Axial, flexural, and shear deformations are lumped at the center of the element and the corresponding internal forces are defined at the center of the deformed element as shown in Fig. 3.1 (b). Axial deformations δ_a, flexural deformations δ_m (change in angle between the two rigid bars), and shear deformations δ_s correspond to axial force T, bending moment M and shear force V at the center of the element.

3.2 Deformation Displacement Relations

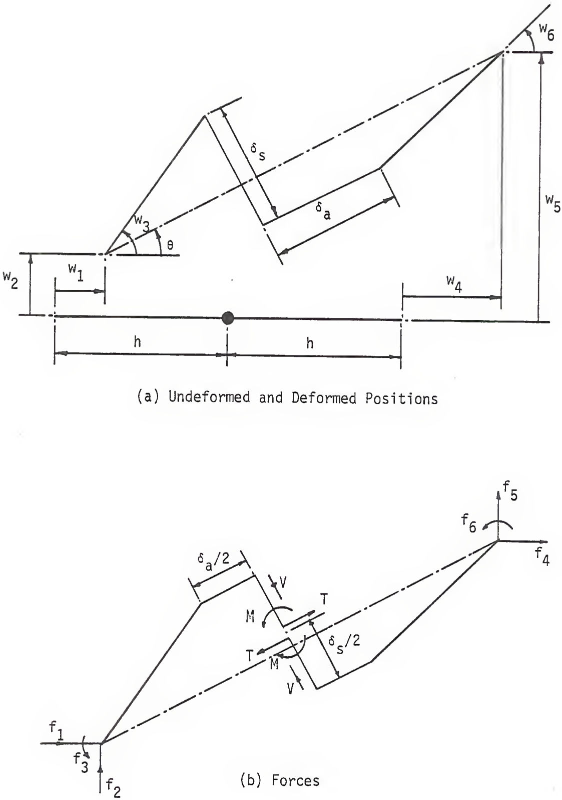
The element end displacements w_1 through w_6 completely define the element deformations δ_a, δ_m, and δ_s. The deformations can be obtained in terms of the end displacements by a simple geometric analysis of model shown in Fig. 3.1 (a).

The angle θ which the line joining the ends of the deformed element makes with the undeformed element direction is given by

$$\theta = \tan^{-1} \left(\frac{w_5-w_2}{2h+w_4-w_1}\right) \tag{3.1}$$

Projection of the deformed element on the line connecting the ends of the deformed element gives

$$\delta_a = (2h+w_4-w_1) \sec\theta - h \cos(w_3-\theta) - h \cos(w_6-\theta) \tag{3.2}$$



(a) Undeformed and Deformed Positions

(b) Forces

Figure 3.1 Discrete Element Shear Model

Projection of the deformed element on the normal to the line connecting the ends of the deformed element gives

$$\delta_s = h \sin(w_3-\theta) + h \sin(w_6-\theta) \tag{3.3}$$

The discrete angle change δ_m is

$$\delta_m = w_6 - w_3 \tag{3.4}$$

Equations 3.1 through 3.4 are the deformation displacement relations. They are valid for large displacements since no small displacement theory approximations are made.

Define the generalized strains $\{\varepsilon\}$ as

$$\{\varepsilon\}^t = [\delta_a, \delta_m, \delta_s] \tag{3.5}$$

and the element end displacements $\{w\}$ as

$$\{w\}^t = [w_1, w_2, w_3, w_4, w_5, w_6] \tag{3.6}$$

Then the incremental relationships take the form

$$\{d\varepsilon\} = [B]\{dw\} \tag{3.7}$$

where [B] is a 3X6 incremental deformation displacement transformation matrix such that

$$B_{ij} = \frac{\partial\varepsilon_i}{\partial w_j} \tag{3.8}$$

3.3 Element End Force — Internal Force Relations

Consider the equilibrium of the free bodies of the rigid bars in Fig. 3.1 (b) to obtain the relationship between the element end forces and the internal forces. Resolving the forces in the horizontal and vertical directions, and taking moment about the end, for each bar give the following relations:

$$f_1 = -T \cos \theta - V \sin \theta \tag{3.9}$$

$$f_2 = -T \sin \theta + V \cos \theta \tag{3.10}$$

$$f_3 = -M + V[h \cos (w_3-\theta) + \frac{\delta_a}{2}] + T[h \sin (w_3-\theta) - \frac{\delta_s}{2}] \quad (3.11)$$

$$f_4 = T \cos \theta + V \sin \theta \quad (3.12)$$

$$f_5 = T \sin \theta - V \cos \theta \quad (3.13)$$

$$f_6 = M + V[h \cos (w_6-\theta) + \frac{\delta_a}{2}] + T[h \sin (w_6-\theta) - \frac{\delta_s}{2}] \quad (3.14)$$

Equations 3.9 through 3.14 are the end force internal force relations.

Define the generalized stress vector $\{\sigma\}$ as

$$\{\sigma\}^t = [T, M, V] \quad (3.15)$$

and the element end force vector $\{f\}$ as

$$\{f\}^t = [f_1, f_2, f_3, f_4, f_5, f_6] \quad (3.16)$$

It is proved in Section 3.5 using virtual work that

$$\{f\} = [B]^t\{\sigma\} \quad (3.17)$$

The set of transformations given by Equations 3.7 and 3.17 is called contragradient (56). However, the end force vector and internal force vector of the discrete element shear model do not satisfy Equation 3.17. The inequality is a function of second order deformation terms and occurs because the shear model is not a pure geometric model. The accuracy of the discrete element shear model is illustrated by the examples of Chapters 8 and 9.

3.4 Internal Force-Deformation Relations

For linear elastic materials, the following internal force-deformation equations hold true:

$$T = \frac{AE}{2h} \delta_a \quad (3.18)$$

$$M = \frac{EI}{2h} \delta_m \quad (3.19)$$

$$V = \frac{1}{k} \frac{A_s G}{2h} \delta_s \quad (3.20)$$

where AE, EI, and A_sG are area times modulus of elasticity, area times second moment of area, and effective shear area times modulus of

rigidity respectively, and k is shear area factor. The curvature at the hinge is approximated by dividing the discrete angle change by 2h. The axial and shear strains are respectively taken as $\delta_a/2h$ and $\delta_s/2h$. For the Equations 3.18 through 3.20 to be correct, the curvature, axial strain, and shear strain need to be small but the displacements need not be small.

For nonlinear stress-strain curves, the relationships between internal forces and deformations can be obtained using the numerical integrations procedure as explained in Chapter 4. Symbolically, Equations 3.21 through 3.23 represent these relations.

$$T = T(\delta_a, \delta_m, \delta_s) \tag{3.21}$$

$$M = M(\delta_a, \delta_m, \delta_s) \tag{3.22}$$

$$V = V(\delta_a, \delta_m, \delta_s) \tag{3.23}$$

Assume that incremental generalized stresses are related to the incremental generalized strains by the following expression:

$$\{d\sigma\} = [D]\{d\varepsilon\} \tag{3.24}$$

where [D] is a 3X3 incremental force deformation matrix and D_{ij} is given by

$$D_{ij} = \frac{\partial\sigma_i}{\partial\varepsilon_j} \tag{3.25}$$

3.5 Discrete Element Shear Tangent Stiffness Matrix

The tangent stiffness matrix [k] of order 6X6 for the discrete element shear model is defined as

$$\{df\} = [k]\{dw\} \tag{3.26}$$

where $\{f\}$ and $\{w\}$ are the member end force and displacement vectors of order 6 and

$$k_{ij} = \frac{\partial f_i}{\partial w_j} \tag{3.27}$$

Forces $\{\sigma\}$ and $\{f\}$ keep the discrete element model under equilibrium. Therefore, principle of virtual work, the virtual work done by the forces on a equilibrium system due to virtual displacement is zero, leads to

$$\delta \underset{\sim}{w}^t \underset{\sim}{f} = \delta \underset{\sim}{\varepsilon}^t \underset{\sim}{\sigma} \tag{3.28}$$

From Eq. 3.7

$$\{\delta\varepsilon\} = [B]\{\delta w\} \tag{3.29}$$

In view of the above expression, Eq. 3.28 becomes

$$\delta \underset{\sim}{w}^t \underset{\sim}{f} = \delta \underset{\sim}{w}^t \underset{\sim}{B}^t \underset{\sim}{\sigma} \tag{3.30}$$

Hence,

$$\underset{\sim}{f} = \underset{\sim}{B}^t \underset{\sim}{\sigma} \tag{3.31}$$

Differentiation of the above equation results in

$$d\underset{\sim}{f} = \underset{\sim}{B}^t d\underset{\sim}{\sigma} + d\underset{\sim}{B}^t \underset{\sim}{\sigma} \tag{3.32}$$

In tensor notation, Eq. 3.32 can be written as

$$df_i = B_{ki}\, d\sigma_k + dB_{ki}\, \sigma_k \tag{3.33}$$

Substitution of Eq. 3.24 and chain rule expansion for dB_{ki} into the above equation gives

$$df_i = B_{ki}\, D_{k\ell}\, d\varepsilon_\ell + B_{ki,j}\, dw_j\, \sigma_k \tag{3.34}$$

Substituting Eq. 3.7 and 3.8 into Eq. 3.34 yields

$$df_i = [B_{ki}\, D_{k\ell}\, B_{\ell j} + \sigma_k\, \varepsilon_{k,ij}]\, dw_j \tag{3.35}$$

Thus, tangent stiffness matrix k_{ij} is given by the following tensor equation:

$$k_{ij} = B_{ki}\, D_{k\ell}\, B_{\ell j} + \sigma_k\, \varepsilon_{k,ij} \tag{3.36}$$

In the explicit form, the above equation can be written as

$$k_{ij} = \sum_{k=1}^{3} \frac{\partial\varepsilon_k}{\partial w_i} \sum_{\ell=1}^{3} \frac{\partial\sigma_k}{\partial\varepsilon_\ell} \frac{\partial\varepsilon_\ell}{\partial w_j} + \sum_{k=1}^{3} \sigma_k \frac{\partial^2\varepsilon_k}{\partial w_i \partial w_j} \tag{3.37}$$

This equation takes the following matrix form:

$$[k] = [k]_c + [k]_s \tag{3.38}$$

where

$$[k]_c = [B]^t [D][B] \tag{3.39}$$

Matrix $[k]_s$ is called the initial stress stiffness matrix and is due to second term of Eq. 3.37, that contributes to k_{ij}. A pure rigid body motion of the discrete element produces no internal stresses σ_k and $[k]_s$ will be a null matrix. Initial stress matrix is computed by adding the terms, obtained by multiplying initial stress with the corresponding second partial derivatives of the deformation displacement equations. It can be observed from Eq. 3.4 that

$$\frac{\partial^2 \delta_m}{\partial w_i \partial w_j} = 0 \quad \text{for } i,\ j = 1 \to 6 \tag{3.40}$$

which implies that there is no contribution to the initial stress matrix from the initial bending moments. Hence, $[k]_s$ can be divided for computational convenience into two components, $[k]_{st}$ and $[k]_{sv}$, which are due to axial and shear forces respectively; i.e.

$$[k]_s = [k]_{st} + [k]_{sv} \tag{3.41}$$

The conventional portion of the stiffness matrix $[k]_c$ is due to the first term of Eq. 3.37. This can easily be computed using the conventional triple matrix product given in Eq. 3.39. The matrices [B], [D], $[k]_{st}$, and $[k]_{sv}$ are provided in Appendix A. It also contains the above matrices for small displacement analysis together with deformation displacement relations and element end force internal force relations.

3.6 Remarks on Member Loads and Restraints

Member loads and restraints are not considered in the above development of force displacement equations for a single discrete element shear model. Member loads are discretized into concentrated loads acting at the member stations and included in the member solution as nodal loads. The same procedure is applicable even to member restraints, for which a series of equivalent concentrated springs are used at the member stations. More information is available in References 22, 23, and 47.

CHAPTER 4

INELASTIC CROSS SECTION RESPONSE FROM NONLINEAR STRESS-STRAIN CURVE AND TANGENT STIFFNESS METHOD

4.1 General

This chapter outlines the method utilized in FRAME82 to obtain the inelastic force deformation response of a cross section. It is an extension of the method that was adopted by Santhanam (47) in his program FRAME63. In addition to the axial and flexural deformations considered by Santhanam, shear deformations are also included in this derivation. It is to be reminded that FRAME82 preserves all the features in FRAME63 and FRAME53, which include inelastic, and nonlinear and linear elastic flexural analyses (22, 47). Only the inelastic cross section response related to the discrete element shear model is presented herein. Tangent stiffness method, which is used to solve a general nonlinear system of equations is also reviewed.

Assumptions and Limitations

A cross section can be constructed of one or several materials of different stress-strain behavior. It is assumed that a cross section can be represented by a series of rectangles. Of course, this is an approximation for a section composed of nonrectangular pieces. It is also assumed that virgin stress-strain curve is defined by a set of piecewise linear segments. Inelastic analysis is restricted to the virgin stress-strain curves which exhibit symmetrical behavior in both tension and compression. The method discussed herein is developed for a

section entirely composed of rectangular pieces whose virgin stress-strain curves are piecewise linear and symmetrical in tension and compression.

The internal forces, namely axial force, bending moment, and shear force are listed as functions of axial, flexural, and shear deformations in Equations 3.21 through 3.23 of Chapter 3. In spite of the above general assumption, to be more realistic, axial force and bending moment are assumed as functions of axial and flexural deformations and shear force is assumed as a function of shear deformations alone. This assumption leads to the following mathematical representation for internal forces:

$$T = T(\delta_a, \delta_m) \tag{4.1}$$

$$M = M(\delta_a, \delta_m) \tag{4.2}$$

$$V = V(\delta_s) \tag{4.3}$$

which implies that interaction between the flexural and shear stresses is ignored. This is justified by the principle of superposition explained in Section 2.5.

Next, a linear strain variation is assumed over the depth of the section to obtain the relations for axial force and bending moment in terms of axial and flexural deformations. Shear strain in a member is generally small compared to the yield shear strain of the material. Hence, a linear elastic shear stress-strain behavior is assumed in FRAME82 for member materials. However, this could be extended to include very general shear stress-strain curve.

4.2 Decomposition of Stress-Strain Curve Using Masing Method

The procedure explained in this chapter is applicable to any generalized relations such as moment-curvature, force-sway, etc., that

exhibit similar behavior as of the stress-strain curve. Consider the virgin stress-strain curve described by the linear segments 0-1-k-ℓ in Fig. 4.1 (a), defined by the coordinates $(\varepsilon_k, \sigma_k)$, k=1,$\ell$. The curve can be represented by ℓ idealized elastic-plastic units or "components." The inelastic response of the given curve can be obtained by adding the responses of each idealized elastic-plastic components. The k th component displayed in Fig. 4.1 (b), defined by (ε_k, Y_k) is derived from Equations 4.4 through 4.6:

$$Y_k = E_k \varepsilon_k \qquad \text{for } k=1,\ell \tag{4.4}$$

where $$E_k = S_k - S_{k+1} \qquad \text{for } 1 \leq k < \ell \tag{4.5}$$

and $$E_k = S_k \qquad \text{for } k=\ell \tag{4.6}$$

S_k is the slope of the linear segment 1-k given in Fig. 4.1 (a).

Consider the particular stress-strain path shown in Fig. 4.1 (a), stressed to position A from the origin and then unloaded to position B. The stress σ and slope E at any point on the path are obtained as

$$\sigma = \sum_{k=1}^{\ell} \bar{\sigma} \tag{4.7}$$

$$E = \sum_{k=1}^{\ell} \bar{E} \tag{4.8}$$

where $\bar{\sigma}$ and $\bar{E}$ are the history dependent stress and slope of the k th component corresponding to strain ε. Note that $\bar{E} = E_k$ when the material is in the "elastic" region and zero otherwise.

Behavior of an Ideal Elastic-Plastic Component Curve and Summation Procedure

The idealistic behavior of the k th elastic-plastic component is shown in Fig. 4.1 (c). A represents the equilibrium position at the end of (n-1) th load increment and εr_k represents the corresponding residual

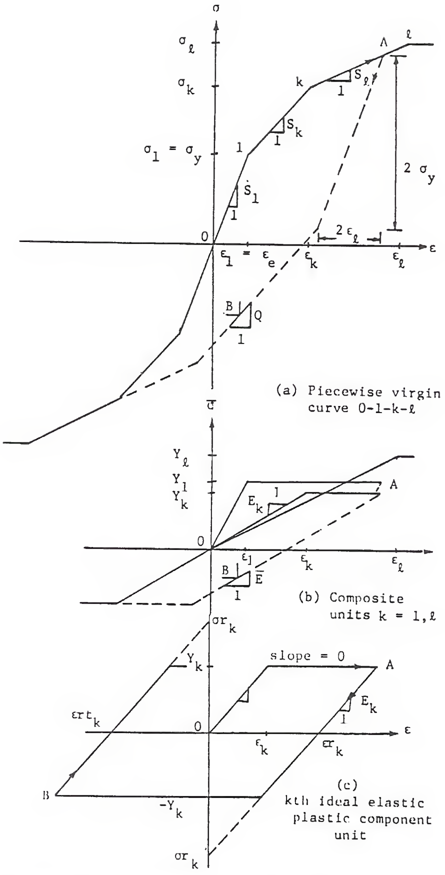


Figure 4.1 Decomposition of General Nonlinear Symmetric Stress-Strain Curve (47)

strain, used to keep track of the deformation path of the k th component. C represents an intermediate point during interaction when equilibrium is not yet established. εrt_k is a temporary variable to denote the residual strain corresponding to point C. If the loading decrement at the n th load step is considerably small, C will be on the "elastic" line through A and εrt_k will coincide with εr_k. Point C will be on the "plastic" line through A if the new load step is an increment. A fictitious stress σr_k shown in Fig. 4.1 (c) is used later in the Equation 4.9. The flow chart in Fig. 4.2 illustrates the above explained procedure to obtain history dependent stress σ and slope Q for a given strain increment. Note that the check for elastic or plastic response of the component is made with respect to εr_k rather than the temporary variable εrt_k.

4.3 Relationship of Generalized Forces and Deformations

A general cross section is shown in Fig. 4.2 (a) with positive coordinate directions. The assumed linear strain distribution over the depth of the section is given in Fig. 4.3 (b). The bending moment at the section is defined about the Z axis through the geometric centroid. Tensile strain and the curvature that causes more tensile strain at the bottom fiber than at the top, are considered positive in this presentation.

A cross section is defined as a series of m rectangles (j = 1, m), each rectangle being of single material of known virgin stress-strain curve as shown in Fig. 4.1 (a). Let stress-strain curve of the j th rectangle have ℓ_j components ($k = 1, \ell_j$). Then each j th rectangle is divided into n_j subrectangles of equal depth ($i = 1, n_j$). It is recommended to use ten equal divisions for a rectangular cross section

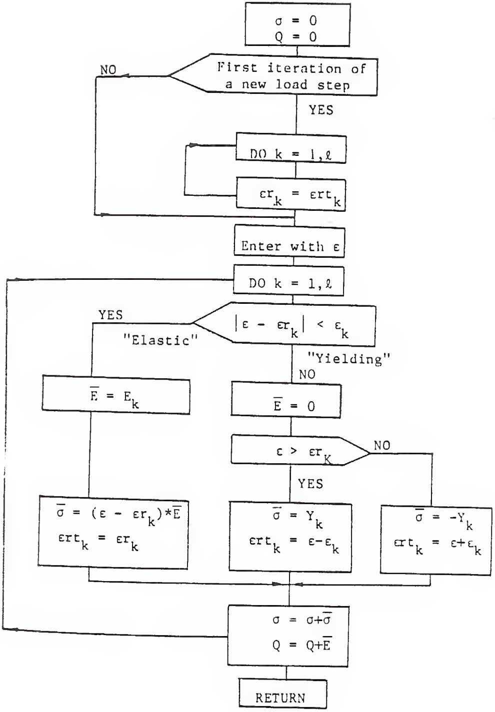
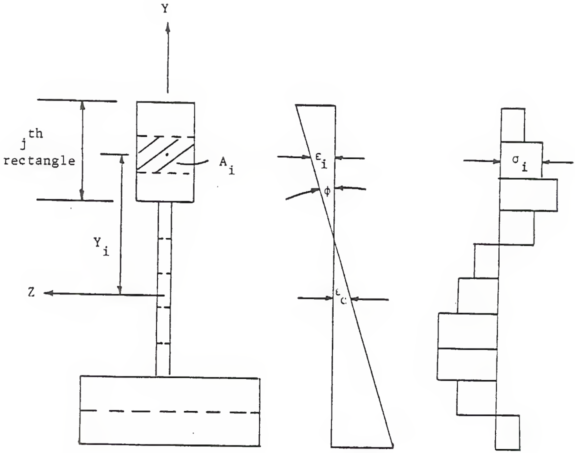


Figure 4.2 Flow Chart for Decomposition of General Nonlinear Symmetric Stress-Strain Curve (47)



(a) A general hybrid section (b) Strain Distributions (c) Stress Distributions

Figure 4.3 Cross Section Definition (47)

and two to four divisions of the flange and four to six divisions on the web for an I-section to obtain good results.

The stress at each subrectangle is assumed uniform over the entire depth of the subrectangle and the strain at the center of the subrectangle is used to obtain this stress. Figure 4.3 (c) shows the typical assumed stress distribution of a cross section.

Referring to the Figures 4.1 (a) and 4.3, and using Equation 4.7, the longitudinal stress σ_i on the i th subrectangle is

$$\sigma_i = \sum_{k=1}^{\ell_j} (\sigma r_k + \bar{E}_k \varepsilon_k) \tag{4.9}$$

in which

$$\bar{E}_k = E_k \tag{4.10}$$

for elastic case

$$\sigma r_k = -E_k \varepsilon r_k \tag{4.11}$$

and

$$\bar{E}_k = 0 \tag{4.12}$$

for plastic case

$$\sigma r_k = \pm Y_k \tag{4.13}$$

and ε_i is the longitudinal strain at the center of i th subrectangle.

The longitudinal strain ε_i can be written in terms of the strain ε_c at the center of the section and curvature ϕ as

$$\varepsilon_i = \varepsilon_c - \phi y_i \tag{4.14}$$

Substitution of Eq. 4.14 in Eq. 4.9 gives

$$\sigma_i = \sum_{k=1}^{\ell_j} (\sigma r_k + \bar{E}_k \varepsilon_c - \bar{E}_k \phi y_i) \tag{4.15}$$

The axial force T_j in the j the rectangle is

$$T_j = \sum_{i=1}^{n_j} \sigma_i A_i \tag{4.16}$$

$$= \frac{A_j}{n_j} \sum_{i=1}^{n_j} \sigma_i \tag{4.17}$$

Hence, the axial force T at the section is given by

$$T = \sum_{j=1}^{m} T_j \tag{4.18}$$

$$= \sum_{j=1}^{m} \frac{A_j}{n_j} \sum_{i=1}^{n_j} \sigma_i \tag{4.19}$$

$$= \sum_{j=1}^{m} \frac{A_j}{n_j} \sum_{i=1}^{n_j} \sum_{k=1}^{\ell_j} (\sigma r_k + \bar{E}_k \varepsilon_c - \bar{E}_k \phi y_i) \tag{4.20}$$

The contribution M_j by the j th rectangle to the total bending moment M is

$$M_j = -\sum_{i=1}^{n_j} \sigma_i A_i y_i \tag{4.21}$$

$$= -\frac{A_j}{n_j} \sum_{i=1}^{n_j} \sigma_i y_i \tag{4.22}$$

Hence, the total moment is given by

$$M = \sum_{j=1}^{m} M_j \tag{4.23}$$

$$= -\sum_{j=1}^{m} \frac{A_j}{n_j} \sum_{i=1}^{n_j} \sigma_i y_i \tag{4.24}$$

$$= - \sum_{j=1}^{m} \frac{A_j}{n_j} \sum_{i=1}^{n_j} y_i \sum_{k=1}^{\ell_j} (\sigma_r + \bar{E}_k \varepsilon_c - \bar{E}_k \phi y_i) \tag{4.25}$$

The shear force V on the j th rectangle is

$$V_j = C_{sj} A_j G_j \gamma \tag{4.26}$$

where

γ = shear strain

G_j = modulus of rigidity of the j th rectagle

C_{sj} = shear area coefficient, equal to inverse of the shear area factor k of the j th rectangle.

Recommended values of C_{sj} for a typical I-section are, 0 for flanges and 1.0 for web.

Thus, the total shear V at the section is

$$V = \sum_{j=1}^{m} V_j \tag{4.27}$$

$$= \gamma \sum_{j=1}^{m} C_{sj} A_j G_j \tag{4.28}$$

The axial force, bending moment, and shear force at the cross section are given respectively by Equations 4.20, 4.25, and 4.28.

4.4 Incremental Force Deformation Matrix

The incremental internal force deformation matrix is defined by Eq. 3.24 and given in Eq. 3.25.

i.e. $$D_{ij} = \frac{\partial \sigma_i}{\partial \varepsilon_j} \quad \text{for } i=1\text{-}3 \text{ and } j=1\text{-}3 \tag{4.29}$$

The generalized stress $\{\sigma\}$ and strain $\{\varepsilon\}$ vectors are defined in Equations 3.15 and 3.5.

i.e. $$\{\sigma\}^t = [T, M, V] \tag{4.30}$$

and $\{\varepsilon\}^t = [\delta_a, \delta_m, \delta_s]$ (4.31)

Therefore, 3X3 matrix [D] can be written in the matrix form as

$$[D] = \begin{bmatrix} \frac{\partial T}{\partial \delta_a} & \frac{\partial T}{\partial \delta_m} & \frac{\partial T}{\partial \delta_s} \\ \frac{\partial M}{\partial \delta_a} & \frac{\partial M}{\partial \delta_m} & \frac{\partial M}{\partial \delta_s} \\ \frac{\partial V}{\partial \delta_a} & \frac{\partial V}{\partial \delta_m} & \frac{\partial V}{\partial \delta_s} \end{bmatrix} \tag{4.32}$$

The relations given in Equations 4.1 through 4.3 for T, M, and V yield

$$\frac{\partial T}{\partial \delta_s} = \frac{\partial M}{\partial \delta_s} = \frac{\partial V}{\partial \delta_a} = \frac{\partial V}{\partial \delta_m} = 0 \tag{4.33}$$

Hence, [D] can be written as

$$[D] = \begin{bmatrix} \frac{\partial T}{\partial \delta_a} & \frac{\partial T}{\partial \delta_m} & 0 \\ \frac{\partial M}{\partial \delta_a} & \frac{\partial M}{\partial \delta_m} & 0 \\ 0 & 0 & \frac{\partial V}{\partial \delta_s} \end{bmatrix} \tag{4.34}$$

Assuming the strains are small, displacements need not necessarily be small, axial strain, curvature, and shear strain can be expressed as in Equations 4.35 through 4.37:

$$\varepsilon_c = \delta_a/2h \tag{4.35}$$

$$\delta = \sigma_m/2h \tag{4.36}$$

$$\gamma = \delta_s/2h \tag{4.37}$$

Substitution of the above equations in Eq. 4.34 leads to

$$[D] = \frac{1}{2h}\begin{bmatrix} \frac{\partial T}{\partial \varepsilon_c} & \frac{\partial T}{\partial \phi} & 0 \\ \frac{\partial M}{\partial \varepsilon_c} & \frac{\partial M}{\partial \phi} & 0 \\ 0 & 0 & \frac{\partial V}{\partial \gamma} \end{bmatrix} \tag{4.38}$$

All the derivatives in Equation 4.38 can be easily obtained from Equations 4.20, 4.25, and 4.28. Remember that σr_k assumes a discrete constant value for a particular load increment and does not vary with ε_c and ϕ.

Therefore,

$$\frac{\partial \sigma r_k}{\partial \varepsilon_c} = \frac{\partial \sigma r_k}{\partial \phi} = 0 \tag{4.39}$$

Differentiation of Eq. 4.20 with respect to ε_c yields

$$\frac{\partial T}{\partial \varepsilon_c} = \sum_{j=1}^{m} \frac{A_j}{n_j} \sum_{i=1}^{n_j} \sum_{k=1}^{\ell_j} \bar{E}_k \tag{4.40}$$

$$= \sum_{j=1}^{m} \frac{A_j}{n_j} \sum_{i=1}^{n_j} E_i \tag{4.41}$$

Note that Eq. 4.8 is substituted in Eq. 4.40 to get Eq. 4.41. Similarly, differentiation of Eq. 4.20 with respect to ϕ yields

$$\frac{\partial M}{\partial \phi} = \sum_{j=1}^{m} \frac{A_j}{n_j} \sum_{i=1}^{n_j} y_i^2 \sum_{k=1}^{\ell_j} \bar{E}_k \tag{4.42}$$

$$\frac{\partial M}{\partial \phi} = \sum_{j=1}^{m} \frac{A_j}{n_j} \sum_{i=1}^{n_j} y_i^{\,2} E_i \tag{4.43}$$

Differentiation of Eq. 4.20 with respect to ε_c and of Eq. 4.25 with respect to ϕ give the same results. Thus,

$$\frac{\partial T}{\partial \phi} = \frac{\partial M}{\partial \varepsilon_c} = - \sum_{j=1}^{m} \frac{A_j}{n_j} \sum_{i=1}^{n_j} y_i \sum_{k=1}^{\ell_j} \bar{E}_k \tag{4.44}$$

$$= -\sum_{j=1}^{m} \frac{A_j}{n_j} \sum_{i=1}^{n_j} y_i \, E_i \tag{4.45}$$

Finally, differentiation of Eq. 4.28 with respect to γ yields

$$\frac{\partial V}{\partial \gamma} = \sum_{j=1}^{m} C_{sj} \, A_j \, G_j \tag{4.46}$$

Incremental internal force deformation matrix [D], also known as the instantaneous tangent stiffness matrix of the element, can be computed using the Equations 4.38, 4.41, 4.43, and 4.45. Matrices [D] of general, and linear elastic and constant prismatic elements are listed in Appendix A.

4.5 Thin Wall Tubular Sections

The program allows input of a member with thin wall tubular cross section. The cross section is subdivided into 20 equal radial segments. A pair of radial segments on either side of the y-axis is combined to obtain the properties of the equivalent rectangle. Thus, ten equivalent rectangular pieces represent the cross section in the numerical integration procedure. The difference in the computed second moment of area, between the thin tubular section approximated by rectangles and perfect thin tubular section is less than one percent (22).

4.6 Brief Description of the Solution Procedure

A brief description, of the solution procedure outlined in Chapter 6, is presented in this section to explain how the discrete element response is related to the overall frame response in the program FRAME82. The framed structure consists of members and joint shear panels. Each member is divided into a finite number of discrete elements which are then subdivided into several layers. Stiffness and End Force matrices of the discrete elements are obtained using the relationships in this and previous chapters.

Member and joint solutions are performed separately to reduce computer time and to avoid large computer storage requirements. Each member is solved individually using as many elements as necessary to obtain each member's stiffness and fixed-end-force matrices. The ends of each member are "held" at the positions corresponding to the current joint displacements to obtain member solutions. Member stiffness and fixed-end-force matrices are computed using the discrete element tangent stiffness and fixed-end-force matrices, and standard matrix analysis techniques. The member and joint stiffness matrices are combined together to form the structural stiffness and load matrices.

Since member and structure solutions are performed separately, an iterative cycle of each member occurs within each iteration on structural joint displacements. Special care needs to be taken to form correct stiffness matrix in the case of inelastic unloading. Tangent stiffness method used in this analysis to obtain nonlinear structural response is referred as Newton-Raphson method in mathematical numerical analysis.

4.7 Tangent Stiffness Method

Consider a system of nonlinear equations of order n, given in Equation 4.47, which involves load vector $\underset{\sim}{P}$ and displacement vector $\underset{\sim}{u}$. The vectors $\underset{\sim}{P}$ and $\underset{\sim}{u}$ represent the joint loads and displacements for joint solution, and member stations loads and displacements for member solution.

$$P_j = P_j\,(u_1, u_2, \ldots u_n) \qquad j=1,2,\ldots,n \qquad (4.47)$$

Assume that $\{P\}_i$ and $\{u\}_i$ at the end of i th load increment are known and the above equation needs to be solved to obtain $\{u\}_{i+1}$ corresponding to $\{P\}_{i+1}$, the load vector at the end of (i+1) th load increment. Define $\{\Delta P\}_i$ and $\{\Delta u\}_i$ as

$$\{P\}_{i+1} = \{P\}_i + \{\Delta P\}_i \qquad (4.48)$$

$$\{u\}_{i+1} = \{u\}_i + \{\Delta u\}_i \qquad (4.49)$$

Expand Equation 4.47 around $\{u\}_i$ using Taylor series:

$$P_j \simeq P_{j,i} + \sum_{k=1}^{n} \frac{\partial P_j}{\partial u_k} (u_k - u_{k,i}) \qquad j=1,2,\ldots n \qquad (4.50)$$

where

$P_{j,i}$ = load P corresponding to j th degree of freedom at the end of i th load increment

u_k = displacement u corresponding to k th degree of freedom

$u_{k,i}$ = value of u_k at the end of i th load increment.

Terms in Equation 4.50 are rearranged to give the following relationship:

$$P_j - P_{j,i} = \Delta P_j = \sum_{k=1}^{n} \frac{\partial P_j}{\partial u_k} \bigg|_{\{u\}_i} (u_k - u_{k,i}) \qquad j=1,2,\ldots,n \qquad (4.51)$$

In the matrix form

$$\{\Delta P\} = [K]_{\{u\}_i} \{u - u,_i\} \tag{4.52}$$

Hence,

$$\{u\}^{(1)} = \{u\}_i^{(0)} + [K]^{-1}_{\{u\}_i^{(0)}} \{P,_{i+1} - P,_i^{(0)}\} \tag{4.53}$$

or

$$\{\Delta u\}^{(0)} = [K]^{-1}_{\{u\}_i^{(0)}} \{\Delta P\}^{(0)} \tag{4.54}$$

Matrix [K] represents the tangent stiffness matrix. Superscripts 0 and 1 denote the values at the beginning of the iteration and after the first iteration respectively.

Since the Taylor expansion in Eq. 4.50 is curtailed after the first order derivative terms, $\{u\}^{(1)}$ obtained in Eq. 4.53 is the first approximation to $\{u\}_{i+1}$. Substitution of $\{u\}_{i+1}$ in Eq. 4.47 will yield a load vector $\{P\}$ which is generally different from $\{P\}_{i+1}$. The difference $\{\Delta P\}$ between $\{P\}_{i+1}$ and P is commonly known as remnant or equilibrium error and defined as

$$\{\Delta P\} = \{P\}_{i+1} - \{P\} \tag{4.55}$$

Successive iterations are required until this error is within the allowable tolerance. Repetition of iteration yields the following algorithm:

$$\{\Delta u\}^{(n)} = [K]^{-1}_{\{u\}^{(n)}} \{\Delta P\}^{n} \tag{4.56}$$

and

$$\{u\}^{(n+1)} = \{u\}^{(n)} + \{\Delta u\}^{(n)} \tag{4.57}$$

where

$$\{\Delta P\}^{(n)} = \{P\}_{i+1} - \{P\}^{(n)} \tag{4.58}$$

Superscripts n and (n+1) denote the values corresponding to the iterative cycles n and (n+1).

The above explained method is presented in References 46 and 56, and geometric interpretation of this procedure is given in Fig. 4.4 for a single degree of freedom system. The flow chart displayed in Fig. 4.5 illustrates the procedure involved in the tangent stiffness method to solve a set of nonlinear equations. An integer is assigned to each stage of the flow chart and stage 4, which is intentionally excluded in this flow diagram, is introduced in the next section that considers the possibility of inelastic unloading.

4.8 Modified Tangent Stiffness Method

The above described tangent stiffness method in Section 4.7 needs to be modified to include the effects of strain reversal. A detailed description of the procedure demonstrated herein is given in Ref. 47. After computing the displacement vector in stage 3 of the flow chart in Fig. 4.5, one should not proceed to stage 5 during first iteration. Rather, compute the strains at each inelastic "component" such as subrectangles, joint shear panels, and member and joint support curves, corresponding to the incremented $\{u\}$. Check whether there is any strain reversal in any component. If none of the components undergo strain reversal, proceed to stage 5.

If a strain reversal is sensed in any component, the entire procedure must be backed up. The history dependent slope of the stress-strain curve corresponding to the inelastic component, which sensed strain reversal, must be replaced with the largest slope of the stress-strain curve, the slope at the origin of the curve. The overall stiffness matrix thus obtained is referred to as "backed-up stiffness matrix." The displacement vector $\{u\}$ must also be set back to the values prior to the strain reversal. This is symbolically represented

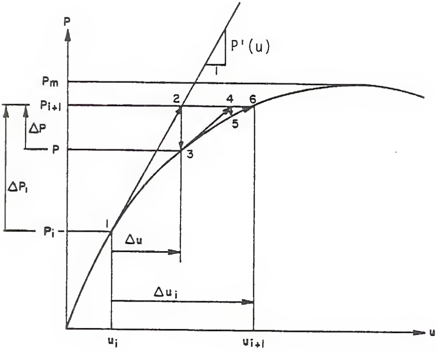


Figure 4.4 Tangent Stiffness Method (22)

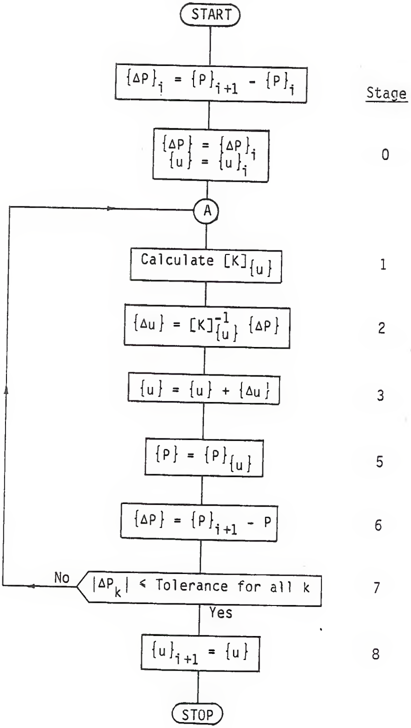


Figure 4.5 Flow Diagram for Tangent Stiffness Method

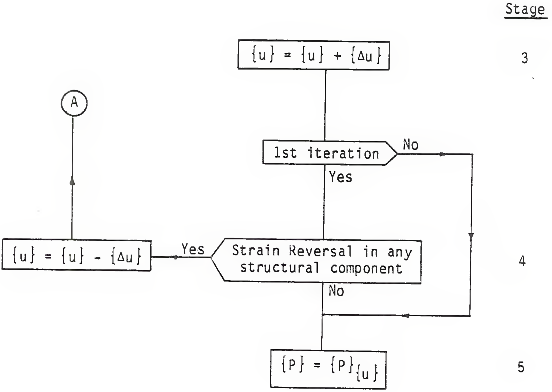


Figure 4.6 Introduced New Stage in Modified Tangent Stiffness Method

as

$$\{u\} = \{u\} - \{\Delta u\} \tag{4.59}$$

Then the stages 1 through 7 are repeated except the formation of backed-up [K] and $\{u\}$, which is referred to as stage 4 in Fig. 4.6, until the solution converges or number of iterations exceeds the specified number of iterations.

Strain Reversal Check

The strain reversal can be directly determined for a single degree of freedom system by comparing the current load with the load history, without solving for incremental deformation. However, the above remark is not applicable to a general system with multiple degree of freedoms. Incremental displacements or deformations must be calculated to find out whether strain reversal has occurred in any subrectangle, joint shear panel or member and joint support curves. It is evident from the decomposition principle explained in Section 4.2 for a general nonlinear curve, that it is necessary to monitor only the first idealized elastic-plastic component to sense any strain reversal in the inelastic components.

CHAPTER 5

SHEAR BEHAVIOR AND STRENGTH OF STEEL JOINTS

5.0 Introduction

Structural frames are usually analyzed assuming that connections are rigid and the sizes of the connections are negligible. While both assumptions simplify the analysis, assuming rigid connection ignores the deformations at the joints and neglecting connection dimensions results in longer member length in the idealized frame than in the real frame, which in turn underestimates the member stiffnesses. In certain structures, the errors caused by the above cited assumptions may be self-compensating. However, in general, the size and the stiffness of the frame connections should be considered in the frame analysis to obtain rational results.

In unbraced frames, structural stability and resistance to lateral loads require the transfer of bending moments between beams and columns. This transfer could be achieved by either semi-rigid or rigid beam-column connections. The beam-column joint will be subjected to high shears whenever a significant unbalance of beam moments is present at the joint. A significant unbalance usually exists at exterior and corner joints, and at the interior joints in the case of lateral load application such as wind or seismic effects.

The shear design of joints is very important in frames that may be subjected to severe earthquake excitations. Such frames may experience stresses and deformations, which are very much higher than the values at

service state. This imposes ductility requirements to be included in the design of frames to ensure serviceability of the structures. This chapter deals with various shear force-shear distortion relationships for joint behavior and the technique to incorporate joint shear behavior in the overall response of the structure.

5.1 Shear Behavior of Joints

The shear behavior of beam-column joints has been the subject of several experimental and analytical studies in recent years (3, 15, 31-35, 42-45). These studies concerned the monotonic and cyclic responses of all types of joints in general and interior joints in particular. Even though beam-column joints can develop failure due to one or combination of the factors such as column web crippling, column web buckling, column flange distortion, and shear yielding and shear buckling of the panel zone, only the shear failure mode of the joint panel is considered in this study. The material presented herein is obtained from references 32, 34, and 35.

The following parameters listed below influence the joint behavior:

(i) Shearing resistance of the panel zone, which is a function of the panel aspect ratio d_b/d_c and the thickness of the shearing area, $t_{cw} + t_s$, where

   d_c = distance between the centroids of the column flanges

   d_b = distance between the centroids of the beam flanges

   t_{cw} = web thickness

   t_s = thickness of the shear reinforcement area parallel to the web

(ii) Effectiveness of the shear reinforcement

(iii) Resistance of the structural components surrounding the panel

zone, which provides the post-elastic reserve strength of the joint. The flexural resistance of the column flanges and in-plane stiffness of the beam webs adjacent to the joint play major role.

(iv) Type of connection

(v) Beneficial effects of column shears - usually oppose the shear force produced in the joints by the beam moments.

(vi) Effects of column axial loads, which must be included in the joint yield criterion.

Several authors have investigated the influence of the parameters listed above on the behavior of joints.

The most important characteristics of the joint behavior are summarized below. The shearing stresses are highest at the center of the joint panels with a moderate but definite drop towards all four corners. When the joints are stressed beyond the elastic limit, yielding in the panel propagates rather slowly from the center of the panel towards the level of beam flanges, for joints that have large aspect ratios (d_b/d_c) and stiff column flanges. Joints with aspect ratio around unity and the column flanges thin and flexible, exhibit uniform yielding through out the panel. The distribution of shear deformations throughout a joint can be studied from the deformed shape of the joint, that is shown for a typical joint in Fig. 5.1 (32). References 32-34 reveal average shear strain and shear stress parameters of the panel, are adequate to model the joint behavior in the overall frame analysis.

The shear stress-strain curve of a joint exhibits an elastic range, followed by a range of gradually decreasing stiffness, and then a strain

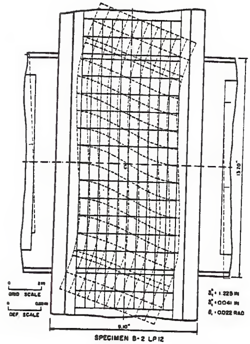


Figure 5.1 Deformations in an Interior Panel Zone (32)

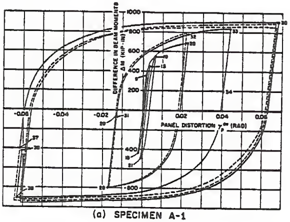


Figure 5.2 Load-Deformation Diagram for a Joint (32)

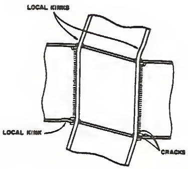


Figure 5.3 Effects of Excessive Joint Distortions (32)

hardening range with constant stiffness. The joint panel remains elastic until the panel zone yields, and in this elastic region, shear resistance is provided mainly by the shear panel. The transition range between elastic stiffness and strain hardening stiffness is governed, primarily by the elements surrounding the panel zone, particularly by the bending resistance of the column flanges and the in-plane stiffness of the beam webs adjacent to the joint. The strain hardening stiffness is largely attributed to the strain hardening in the material.

Properly detailed joints exhibit a remarkable ductility and very stable and repetitive hysteresis loops under cyclic loading as displayed in Fig. 5.2 (32). No drop in strength is noticeable in such joints, even at extremely large inelastic distortions. However, under large distortions diagonal buckling might be observed in thin joint panels, and continued joint distortion would cause the formation of local kinks in beams and columns flanges outside the joint, as illustrated in Fig. 5.3, and could lead to the fracture of the material. The fracture would occur only after several load reversals at extremely large joint distortions.

5.2 Shear Force-Shear Distorsion Relationships for Joints

Krawinkler (32), Krawinkler et al. (34, 35) and Fielding (15) have recommended relationships to predict the behavior of joints based on their experimental investigations and analytical behavior of joints. Although the above authors utilized shear force and shear deformation, of the joint, as the parameters to describe the joint behavior, average shear stress and deformation are used in this presentation to be compatible with input stress-strain curves for members. An analytical joint shear stress-strain curve is derived from uniaxial stress-strain

curve and later modified to comply with the experimental observations made by the above two authors.

5.2.1 Krawinkler Model

The mathematical model used by Krawinkler to derive expressions to represent the joint behavior is displayed in Fig. 5.4. It consists of an ideal elastic-plastic shear panel surrounded by rigid boundaries with springs at the four corners. These springs simulate the resistance of the elements surrounding the panel zones, in particular the bending resistance of column flanges.

The shear panel provides most of the resistance by shear deformations, until the average shear strain attains the yield shear strain. Thus, the joint shear stress in the elastic range is given by

$$\tau = G\gamma \qquad 0 \leq \gamma \leq \gamma_y \tag{5.1}$$

where

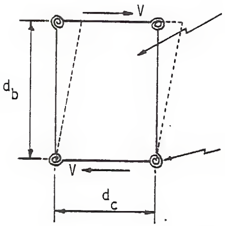
τ = shear stress

γ = shear strain

G = shear modulus

γ_y = yield shear strain $\left(= \dfrac{\tau_y}{\sqrt{3}G}\right)$

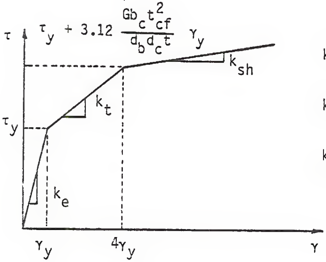
The increase in strength beyond τ_y is attributed to the resistance of elements surrounding the panel zone, especially due to the flexural resistance of the column flanges. This resistance is represented by springs at four corners, whose stiffness is that corresponding to concentrated rotations of column flanges at each corner. When the boundary of the panel zones are assumed to be rigid, this spring stiffness is approximated by



$$k_e = G \text{ for } 0 < \gamma < \gamma_y$$
$$= 0 \text{ for } \gamma_y < \gamma < 4\gamma_y$$
$$= G_{sh} \text{ for } 4\gamma_y < \gamma$$

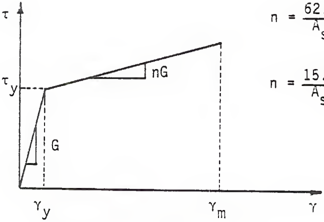
$$k_s = \frac{M}{\theta} = \frac{Eb_c t_{cf}^2}{10} \text{ for } \gamma_y < \gamma < 4\gamma_y$$
$$= 0 \quad \text{otherwise}$$

Figure 5.4 Mathematical Model for Joint by Krawinkler



$$k_e = G$$
$$k_t = 1.04 \frac{Gb_c t_{cf}^2}{d_b d_c t}$$
$$k_{sh} = G_{sh} = E_{sh}/2.6$$

Figure 5.5 Krawinkler Model



$$n = \frac{62.4}{A_s} \frac{I_f}{d_g^2} \quad \text{for interior and exterior joints}$$
$$n = \frac{15.6}{A_s} \frac{I_f}{d_g^2} \quad \text{for corner joints}$$

Figure 5.6 Fielding Model

$$k_s = \frac{M}{\theta} = \frac{Eb_c t_{cf}^2}{10} \tag{5.2}$$

The work equation gives

$$d_b \Delta v \Delta \gamma = 4M\theta \tag{5.3}$$

where

$$\theta = \Delta\gamma \tag{5.4}$$

and

$$\Delta v = \Delta\tau d_c t \tag{5.5}$$

in which $t = t_{cw} + t_s$ = equivalent thickness of the shear panel. In view of Equations 5.4 and 5.5, Equation 5.3 becomes

$$\frac{\Delta\tau}{\Delta\gamma} = \frac{4M}{d_b d_c t\theta} \tag{5.6}$$

Feeding Eq. 5.2 into the above equation leads to

$$\frac{\Delta\tau}{\Delta\gamma} = \frac{4Eb_c t_{cf}^2}{10 d_b d_c t} \tag{5.7}$$

Substitution of $E = 2.6G$ in Eq. 5.7 gives the post-yield stiffness for the range $\gamma_y < \gamma \leq 4\gamma_y$.

i.e. $$\frac{\Delta\tau}{\Delta\gamma} = 1.04 \frac{Gb_c t_{cf}^2}{d_b d_c t} \tag{5.8}$$

Even though the expression derived in Eq. 5.8 holds true only until yielding occurs in the column flange, the finite element study (34) showed that it is valid up to $\gamma = 4\gamma_y$, the shear strain value at which the column flanges nearly attain their full plastic moment capacity. Hence, the joint shear stress is expressed as

$$\tau = \tau_y + 1.04 \frac{Gb_c t_{cf}^2}{d_b d_c t} (\gamma - \gamma_y) \qquad \gamma_y < \gamma \leq 4\gamma_y \tag{5.9}$$

If the joint is strained beyond $4\gamma_y$, strain hardening in the panel zone usually develops and the strain hardening stiffness is equivalent to $E_{sh}/2.6$. Therefore, the joint shear stress can be written as

$$\tau = \tau_y + 3.12 \frac{Gb_c t_{cf}^2}{d_b d_c t} \gamma_y + \frac{E_{sh}}{2.6}(\gamma - 4\gamma_y) \qquad \gamma > 4\gamma_y \tag{5.10}$$

The joint shear stress-strain model recommended by Krawinkler is given in Fig. 5.5, along with the critical values. This model is expected to give good results for interior joints when the axial column load ratio P/P_y is less than 0.50 and when the combined action of axial load and bending moment in the column will not cause yielding outside the joint, since early yielding of the column will decrease the resistance of elements surrounding the panel zone. This model is not applicable to corner joints which are bounded by framing elements only in two faces of the panel zone. When two beams of different depth frame into the column in interior joints, it is conservative to use the larger value of d_b in joint stress calculations.

5.2.2 Fielding Model

Fielding and Chen (15) assumed a bilinear model shown in Fig. 5.6 to represent the behavior of joint. Until the shear panel yields ($\gamma \leq \gamma_y$), the shear panel deformation is assumed to provide the entire shear resistance.

i.e. $$\tau = G\gamma \qquad 0 \leq \gamma \leq \gamma_y \tag{5.11}$$

The strain-hardening stiffness of the inelastic region is obtained by considering the stiffness of the connection boundary elements (column flanges and horizontal stiffeners). These plate elements are assumed to bend in a frame type manner subsequent to softening of the shear panel due to shear yielding. In this range the deformation of the column web is assumed not to contribute to the additional connection capacity until strain hardening of the web begins. It has been found that flexural rigidity of the column flanges chiefly influences the load carrying capacity of webs in shear.

The obtained post-yield stiffness parameter for interior and exterior connections is

$$n = \frac{62.4}{A_s} \frac{I_f}{d_g^2} \tag{5.12}$$

and for corner connections is

$$n = \frac{15.6}{A_s} \frac{I_f}{d_g^2} \tag{5.13}$$

where d_g = girder depth; A_s = effective shear area of the column web (product of the web thickness and the distance between flange centroids); and I_f = the moment of inertia of the column flange. Thus,

$$I_f = \frac{1}{12} b_c t_{cf}^3 \tag{5.14}$$

in which b_c = column flange width; and t_{cf} = column flange thickness.

For the post-yield stiffness parameter n defined by Eqs. 5.12 and 5.13 to be valid, the column web must not go into the strain hardening

region and the column flanges should not reach their full plastic moment capacities. Since it is found in experimental investigations carried out by Krawinkler (32) and Krawinkler et al. (34, 35) that the previously outlined conditions break down at $\gamma=4\gamma_y$, it is reasonable to assume that the model recommended by Fielding holds good up to $\gamma_m=4\gamma_y$, where γ_m = maximum average shear deformation.

5.2.3 Modified Analytical Model

Analytical derivation of joint shear stress-strain curve from uniaxial stress-strain curve, described herein, yields a new model. Since this model does not include the resistance provided by the structural elements surrounding the joint panel zone, it has to be modified for the shear strain range $\gamma_y<\gamma\leq 4\gamma_y$ to obtain a better model that would predict good results. The stiffness recommended by either Krawinkler or Fielding can be used in the range $\gamma_y<\gamma\leq 4\gamma_y$, where the column flanges offer a significant contribution, to modify the analytical model.

Derivation of τ-γ Curve from σ-ε Curve

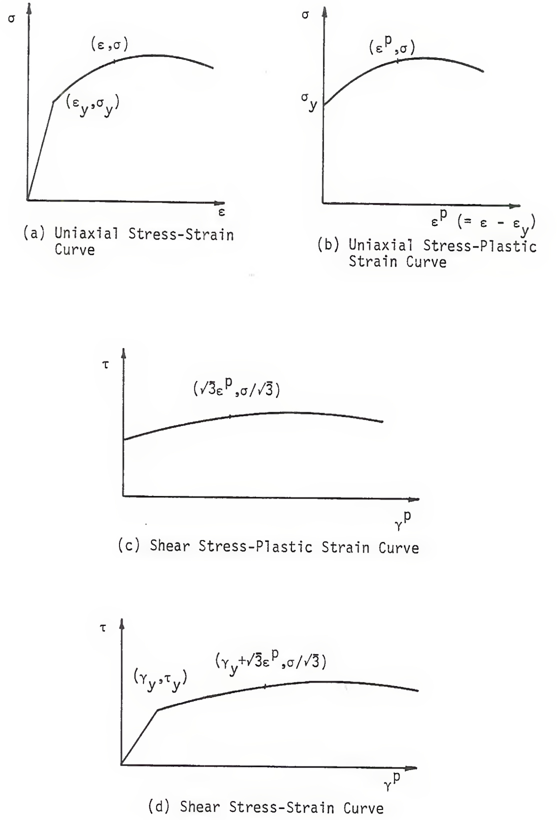
Consider a general uniaxial stress-strain curve given in Fig. 5.7 (a) to obtain the joint shear stress-strain curve. Levy-Mises yield criterion and the isotropic-hardening Levy-Mises theory described in Ref. 37 are used to obtain the required relationship. No distinction is made between natural and nominal strains in this derivation since the strain is assumed small.

Mises yield criterion is given by

$$J_2' = k^2 \tag{5.15a}$$

or

$$\frac{1}{2}\sigma_{ij}'\sigma_{ij}' = k^2 \tag{5.15b}$$



(a) Uniaxial Stress-Strain Curve

(b) Uniaxial Stress-Plastic Strain Curve

(c) Shear Stress-Plastic Strain Curve

(d) Shear Stress-Strain Curve

Figure 5.7 Graphical Representation of the Derivation of Shear Stress-Strain Curve from Uniaxial Stress-Strain Curve

where J_2' = second invariant of the deviatoric stress tensor; σ_{ij}' = deviatoric stress on the plane i along the direction j; k = a constant. Deviatoric stress σ_{ij}' is defined as

$$\sigma_{ij}' = \sigma_{ij} - p\delta_{ij} \tag{5.16}$$

where σ_{ij} = stress; and p = mean normal stress and given by

$$p = \frac{(\sigma_{11} + \sigma_{22} + \sigma_{33})}{3} \tag{5.17}$$

Eq. 5.15b can be rewritten as

$$J_2' = k^2 = \frac{1}{6}[(\sigma_{11}-\sigma_{22})^2 + (\sigma_{22}-\sigma_{33})^2 + (\sigma_{33}-\sigma_{11})^2] + \sigma_{23}^2 + \sigma_{31}^2 + \sigma_{12}^2 \tag{5.18}$$

For uniaxial stress σ_{11}, the space is one dimensional and the condition defining the yield surface is given by

$$|\sigma_{11}| = \sigma_y \tag{5.19}$$

Substitution of Eq. 5.19 into Eq. 5.18 leads to

$$k^2 = \frac{1}{6}(2\sigma_y^2) = \frac{\sigma_y^2}{3} \tag{5.20}$$

For pure shear in the xy plane, $\sigma_{12} = \sigma_{21} = \tau_y$ and the rest of the σ_{ij}s are zero. Substitute these conditions into Eq. 5.18 and obtain

$$k^2 = \tau_y^2 \tag{5.21}$$

In view of Eq. 5.20 and 5.21, the yield shear stress is

$$\tau_y = \sigma_y/\sqrt{3} \tag{5.22}$$

and the corresponding yield shear strain is

$$\gamma_y = \tau_y/G \tag{5.23}$$

Isotropic hardening assumption, that the yield surface maintains its shape, while its size increase is controlled by a single parameter depending on the plastic deformation, is used to obtain the shear stress-strain curve in the inelastic region. The universal plastic stress-strain curve defined by two scalar quantities, the effective stress $\bar{\sigma}$ and the integral of the effective plastic-strain increment $d\bar{\varepsilon}_p$, governs the yield surface. When used with the Mises yield condition, the appropriate effective stress $\bar{\sigma}$ is

$$\bar{\sigma} = \sqrt{3J_2'} = \left[\frac{3}{2}\sigma'_{ij}\sigma'_{ij}\right]^{\frac{1}{2}} = \tfrac{1}{2}\left[\{(\sigma_{11}-\sigma_{22})^2 + (\sigma_{22}-\sigma_{33})^2 + (\sigma_{33}-\sigma_{11})^2\} + 3(\sigma_{23}^2 + \sigma_{31}^2 + \sigma_{12}^2)\right]^{\frac{1}{2}} \tag{5.24}$$

and the appropriate effective strain increment $d\bar{\varepsilon}_p$ to use with $\bar{\sigma}$ is

$$d\bar{\varepsilon}_p = \left[\frac{4}{3}\Pi_{d\varepsilon^p}\right]^{\frac{1}{2}} = \left[\frac{2}{3}d\varepsilon^p_{ij}d\varepsilon^p_{ij}\right]^{\frac{1}{2}} = \left[\tfrac{2}{9}\{(d\varepsilon^p_{11}-d\varepsilon^p_{22})^2 + (d\varepsilon^p_{22}-d\varepsilon^p_{33})^2 + (d\varepsilon^p_{33}-d\varepsilon^p_{11})^2\} + \tfrac{4}{3}\{(d\varepsilon^p_{23})^2 + (d\varepsilon^p_{31})^2 + (d\varepsilon^p_{12})^2\}\right]^{\frac{1}{2}} \tag{5.25}$$

where $\Pi_{d\varepsilon^p}$ = second invariant of the plastic strain increment tensor.

For uniaxial stress σ_{11}, all the stress components are zero other than σ_{11}. Hence, the effective stress defined in Eq. 5.24 becomes

$$\bar{\sigma} = \sigma_{11} \tag{5.26}$$

Plastic incompressibility implies the following condition:

$$d\varepsilon_{22}^{p} = d\varepsilon_{33}^{p} = -\frac{1}{2}\,d\varepsilon_{11}^{p} \qquad (5.27)$$

Substitution of Eq. 5.27 in Eq. 5.25 yields the effective plastic strain increment as

$$d\bar{\varepsilon}_{p} = d\varepsilon_{11}^{p} \qquad (5.28)$$

For pure shear in the xy plane, all the stress components other than σ_{12} and σ_{21}, and all the strain increment components other than ε_{12}^{p} and ε_{21}^{p} are zero. Hence, Eqs. 5.24 and 5.25 give the effective stress and plastic strain increment in the following expressions:

$$\bar{\sigma} = \sqrt{3}\,\sigma_{12} \qquad (5.29)$$

$$d\bar{\varepsilon}_{p} = \frac{2}{\sqrt{3}}\,d\varepsilon_{12}^{p} = \frac{d\gamma_{12}^{p}}{\sqrt{3}} \qquad (5.30)$$

Equations 5.26 and 5.29, and 5.28 and 5.30 provide the required relationships between uniaxial and sher stress-strain curves in the inelastic region.

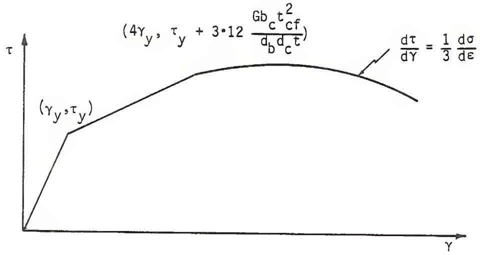
i.e. $$\sigma_{12} = \frac{1}{\sqrt{3}}\,\sigma_{11} \qquad (5.31)$$

and $$d\gamma_{12}^{p} = \sqrt{3}\,d\varepsilon_{11}^{p} \qquad (5.32)$$

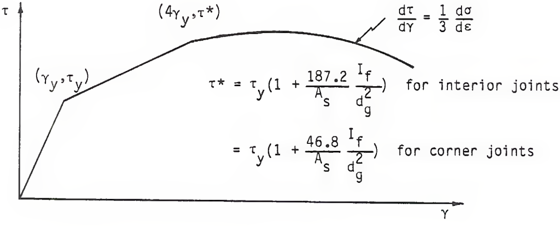
The slope of the shear stress-strain curve in the inelastic region is obtained from the above two equations as

$$\frac{d\sigma_{12}}{d\gamma_{12}^{p}} = \frac{1}{3}\,\frac{d\sigma_{11}}{d\varepsilon_{11}^{p}} \qquad (5.33)$$

Equations 5.22 and 5.23, and 5.33 are used to obtain the shear stress-strain curve in the linear elastic and inelastic regions respectively.



(a) Analytical Curve with Krawinkler Recommendations



(b) Analytical Curve with Fielding Recommendations

Figure 5.8 Analytical Shear Stress-Strain Models for Joints

Figure 5.7 (b) shows the uniaxial stress versus plastic strain (strain-yield strain) curve. Stress ordinates are shrunk by a factor of $\sqrt{3}$, while plastic strain abscissae are stretched by $\sqrt{3}$ to obtain the shear stress-plastic shear strain curve in Fig. 5.7 (c). Linear elastic segment of the shear stress-strain curve is added to Fig. 5.7 (c) to derive Fig. 5.7 (d), the analytical shear stress-strain curve.

The shear stress-strain curve of the web (and stiffeners) can be derived from its uniaxial stress-strain curve. This has to be modified to include the effects of elements around the panel zone in the shear strain range, γ_y to $4\gamma_y$. This could be achieved by using the relationships suggested by Krawinkler and Fielding in the above mentioned range. It is worthwhile to note that elastic shear strain curve is the same for all the models that are discussed in this chapter, including the analytical model. Therefore, no matter whose model is employed to include the effects of elements surrounding the panel zone, the difference from the particular model would be only in the strain hardening region beyond $4\gamma_y$. The modified analytical models corresponding to Krawinkler and Fielding models are displayed in Figs. 5.8 (a) and 5.8 (b). It is interesting to observe that Krawinkler model uses 2.6 instead of 3.0 used in the modified analytical model, in the strain hardening range beyond $4\gamma_y$.

5.3 Four Degree of Freedom Joint Stiffness Matrix

The shear strain γ_{xy} at any point in a solid continuum is given by

$$\gamma_{xy} = \left(\frac{\partial u_x}{\partial Y} + \frac{\partial u_y}{\partial X}\right) \tag{5.34}$$

where (u_x, u_y) are displacement components of the point parallel to the

X and Y axes. Consider the deformation shape of a rectangular panel subjected to pure shear deformation in Fig. 5.9 (a). The rotations θ_1 and θ_2 of the fibers parallel to x and y axes are defined by

$$\theta_1 = \frac{\partial u_y}{\partial X} \tag{5.35a}$$

$$\theta_2 = \frac{\partial u_x}{\partial Y} \tag{5.35b}$$

Hence, $\gamma_{xy} = \theta_1 + \theta_2$ (5.35c)

For pure shear deformation

$$\theta_1 = \theta_2 \tag{5.36}$$

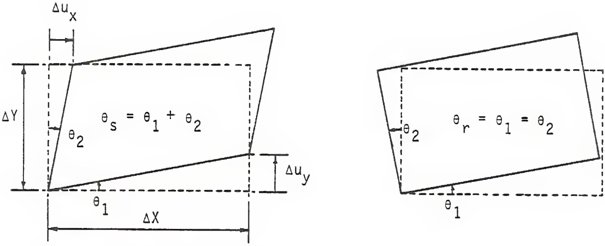
Figure 5.9 (b) displays a rectangular panel that is undergoing a pure rigid body motion. Any fiber in the panel is rotated by the same angular movement.

i.e. $\theta_1 = \theta_2$ (5.37)

Note that θ_2 is defined in opposite directions in Figs. 5.9 (a) and (b) for convenience.

It is imperative to include an additional degree of freedom for each joint, to the generally used three degrees of freedoms, namely horizontal, vertical, and rotational displacements, to incorporate the joint shear deformation in the frame analysis. Translational displacements of the geometric centroid of the shear panel along the x, y directions and rotational displacements of both x, y axes are chosen as the four degrees of freedom in this study. The following assumptions are necessary to simplify the analysis.

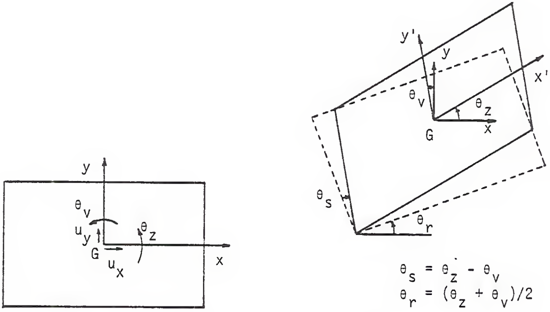
(i) Shear panel is of rectangular shape with constant thickness and its edges are parallel to the x, y axes before being stressed.



(a) Pure Shear Deformation with No Rigid Body Rotation

(b) Rigid Body Rotation

Figure 5.9 Shear Deformation and Rigid Body Rotation of a Rectangular Shear Panel



(a) Undeformed Panel

(b) Deformed Panel

Figure 5.10 Rectangular Shear Panel with Four Degrees of Freedom

(ii) Shear panel experiences a constant-shear-flow distribution.

(iii) Joint may undergo large rotations, but the deformation, or change in rotation, is small.

First, a four degree of freedom stiffness matrix is derived for a rectangular joint shear panel of constant modulus of rigidity and later, it is modified to include the inelastic behavior of the shear panel.

Constant shear flow distribution assumption implies that the geometry of any point within the shear panel can be defined in terms of the selected four degrees of freedom at the geometric centroid of the panel. The chosen degrees of freedom u_x, u_y, θ_z and θ_v, which denote x-displacement, y-displacement, x-axis rotation, and y-axis rotation respectively, are shown in Fig. 5.10. Let the respective forces be f_x, f_y, m_z, and m_v, where the moments m_z and m_v represent the couples produced by the shear forces along the edges perpendicular to x and y axes respectively. These moments are equal and opposite in direction, for a shear panel undergoing pure rigid body motion. The rigid body rotation of the shear panel corresponding to any deformation is displayed in dashed lines through the lower most corner of the panel to define rigid body rotation θ_r and shear deformation θ_s in terms of θ_z and θ_v.

Application of Eq. 5.36 to the deformed rectangular shear panel in Fig. 5.10 gives the following relationship.

$$\theta_z - \theta_r = \theta_r - \theta_v$$

i.e.

$$\theta_r = (\theta_z + \theta_v)/2 \qquad (5.38)$$

Similarly, application of Eq. 5.35c leads to

$$\theta_s = (\theta_z - \theta_r) + (\theta_r - \theta_v)$$

i.e.

$$\theta_s = (\theta_z - \theta_v) \tag{5.39}$$

Linear Elastic Joint Shear Stiffness Matrix

The elastic joint stiffness matrix [k], joint forces {f}, and displacements {w} are related to each other by the following equation:

$$\{f\} = [k]\{w\} \tag{5.40}$$

where

$$\{f\}^t = [f_x, f_y, m_z, m_v] \tag{5.41}$$

$$\{w\}^t = [u_x, u_y, \theta_z, \theta_v] \tag{5.42}$$

$$[k] = Gabt \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & -1 \\ 0 & 0 & -1 & 1 \end{bmatrix} \tag{5.43}$$

in which G = elastic shear modulus; a = undeformed length of the shear panel parallel to x axis; b = undeformed length of the shear panel parallel to y axis; t = undeformed thickness of the shear panel.

Incremental Joint Shear Stiffness Matrix

Incremental joint stiffness matrix [k] is related to the incremental joint force vector {df} and incremental displacement vector {dw} by the following expression:

$$\{df\} = [k]\{dw\} \tag{5.44}$$

where

$$\{df\}^t = [df_x, df_y, dm_z, dm_v] \tag{5.45}$$

$$\{dw\}^t = [du_x, du_y, d\theta_z, d\theta_v] \tag{5.46}$$

$$[k] = G_t abt \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & -1 \\ 0 & 0 & -1 & 1 \end{bmatrix} \tag{5.47}$$

in which G_t = slope of the joint shear stress-strain curve at the current deformed configuration.

5.4 Member Stiffness Matrix in Four Degree of Freedom Structural Coordinates

Since the joint stiffness matrix is associated with four degrees of freedom, it is required to transform the member stiffness matrix formulated in three degree of freedom structural coordinate system into four degree of freedom structural coordinate system to include joint deformation effects in the analysis. Thus, a member stiffness matrix of order 6X6 would become an 8X8 member stiffness matrix. A member stiffness matrix can be written as

$$[k] = \begin{bmatrix} [k_{11}] & [k_{12}] \\ [k_{21}] & [k_{22}] \end{bmatrix} \tag{5.48}$$

where the suffixes 1, 2 in the submatrices represent the to and from joints. The order of each square submatrix is equal to the number of degrees of freedom. If the transformation matrices are known at the to and from ends, then the submatrices of the transformed stiffness matrix can be obtained using the following transformation relationship (56):

$$[k_{IJ}]_{4X4} = [T_I]^t_{4X3} \; [\bar{k}_{IJ}]_{3X3} \; [T_J]_{3X4} \tag{5.49}$$

where [T] is the transformation matrix and I, J could represent either

from or to ends of the member. It is to be remembered that [T] relates the three degree of freedom member displacements $\{\bar{w}\}$ to the four degree of freedom joint displacements $\{w\}$ as given in Eq. 5.50:

$$\{d\bar{w}\}_{3X1} = [T]_{3X4}\,\{dw\}_{4X1} \tag{5.50}$$

As the joint stiffness matrix is known only for the rectangular panel, the present analysis is restricted to rectangular frames with no diagonal bracings. The required transformation matrices are derived herein for both horizontal and vertical member ends.

Transformation Matrices

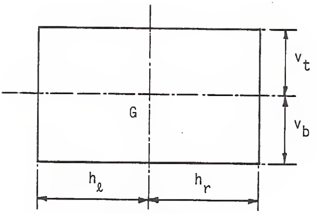
Transformation matrices need to be derived for four cases, namely shear panel at the from end of horizontal member, shear panel at the to end of horizontal member, shear panel at the from end of vertical member, and shear panel at the to end of vertical member. The dimensions of the rectangular panel used are given in Fig. 5.11 (a). Figure 5.11 (b) is considered for the derivation of transfer matrices for horizontal and vertical members. Since the derivation of transfer matrices is very similar for all four cases detailed derivation is provided only for the case of shear panel at the from end of horizontal member. However, the transfer matrices of other cases are also listed herein.

Consider the joint shear panel and horizontal member at the right in Fig. 5.11 (b) to obtain the relationship between member displacements $\{\bar{w}\}$ and joint displacements $\{w\}$ for the case of shear panel at the from end of horizontal member, where

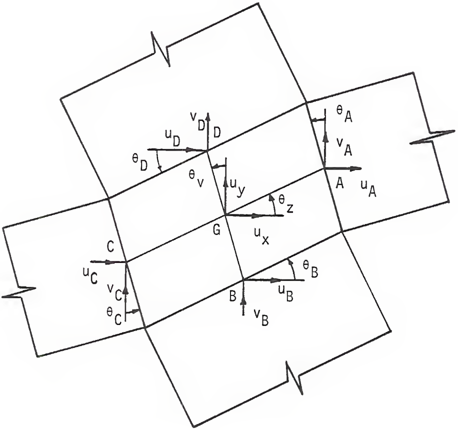
$$\{\bar{w}\}^t = [u_A,\ v_A,\ \theta_A] \tag{5.51}$$

$$\{w\}^t = [u_x,\ u_y,\ \theta_z,\ \theta_v] \tag{5.52}$$

From geometry



(a) Dimensions



(b) Shear Panel and Member End Displacements

Figure 5.11 Rectangular Shear Panel

$$u_A = u_x + h_r \cos \theta_z \qquad (5.53a)$$

$$v_A = u_y + h_r \sin \theta_z \qquad (5.53b)$$

$$\theta_A = \theta_v \qquad (5.53c)$$

where, h_r = horizontal distance of the right vertical edge from the geometric centroid of the panel. Differentiation of the set of equations in Eqs. 5.53 yields

$$du_A = du_x - h_r \sin \theta_z \, d\theta_z \qquad (5.54a)$$

$$dv_A = du_y + h_r \cos \theta_z \, d\theta_z \qquad (5.54b)$$

$$d\theta_A = d\theta_v \qquad (5.54c)$$

Hence, the transformation matrix [T] is given by

$$[T] = \begin{bmatrix} 1 & 0 & -h_r \sin\theta_z & 0 \\ 0 & 1 & h_r \cos\theta_z & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \qquad (5.55)$$

The transformation matrix for the case of <u>shear panel at the to end of horizontal member</u> is given by

$$[T] = \begin{bmatrix} 1 & 0 & h_\ell \sin\theta_z & 0 \\ 0 & 1 & -h_\ell \cos\theta_z & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \qquad (5.56)$$

where h_ℓ = horizontal distance of the left vertical edge from the centroid of the panel.

The transformation matrix for the case of <u>shear panel at the from end of vertical member</u> is given by

$$[T] = \begin{bmatrix} 1 & 0 & 0 & -v_t\cos\theta_v \\ 0 & 1 & 0 & -v_t\sin\theta_v \\ 0 & 0 & 1 & 0 \end{bmatrix} \quad (5.57)$$

where v_t = vertical distance of the top horizontal edge from the centroid of the panel.

The transformation matrix for the case of <u>shear panel at the to end of vertical member</u> is given by

$$[T] = \begin{bmatrix} 1 & 0 & 0 & v_b\cos\theta_v \\ 0 & 1 & 0 & v_b\sin\theta_v \\ 0 & 0 & 1 & 0 \end{bmatrix} \quad (5.58)$$

where v_b = vertical distance of the bottom horizontal edge from the centroid of the panel.

5.5 General Comments on DRAIN 2D Analysis

DRAIN 2D, the program developed by Kanaan and Powell (30), also uses a constant shear-flow infill panel element to incorporate the effects of joint shear deformation in the analysis. The element is assumed either rectangle or very close to a rectangle in shape. Flexural and axial deformations are ignored in the analysis. The infill panel element is treated as an isoparametric finite element with eight degrees of freedom, two translational degrees of freedom at the center of each boundary. The infill panel element is connected to beam-column members at nodes. In general, the infill panel element would have four nodes. A beam-column member has two nodes (one at each end) with three degrees of freedom (two translational, one rotational) per node.

Large displacement effects which are included in the FRAME82 analysis, are not taken into account in the DRAIN 2D analysis. The effect of semi-rigid connection element incorporated in the DRAIN 2D analysis can be obtained by inputting a proper joint shear stress-strain curve in FRAME82 analysis.

CHAPTER 6

FRAME ANALYSIS

6.1 Assumptions

The following assumptions are made to derive the theory used in the development of the program FRAME82:

(1) Plane frame - displacements and forces are in the plane of the frame.

(2) The deformations (strains and curvature) are of an infinitesimal order, though the displacements (axial, lateral and rotational) can be finite and large.

(3) Linear strain distribution across the depth of a cross section.

(4) Member shear strain is in the linear eleastic range. No interaction between shear strain, and axial and flexural strains is considered for members in the strain hardening region.

(5) Shear deformations of joint is included - axial and flexural deformations are neglected.

(6) A general stress-strain curve is assumed for member flexural and joint shear curves.

(7) First assumption implies that out-of-plane buckling cannot be considered. Local buckling of flanges and web is also not included.

(8) In a dynamic analysis, masses are lumped at the structural joints.

(9) Acceleration is constant within each time step since constant average acceleration method is employed.

(10) Mass and stiffness dependent damping is assumed.

(11) Residual stresses are not included in the analysis.

6.2 Outline of the Solution Procedure

The structure is idealized as an assemblage of members and joint shear panels. Each joint (node) possesses either three or four degrees of freedom depending on whether the joint shear deformations are included or ignored. The analysis that includes joint shear deformations utilizes an additional rotational degree of freedom per node, as explained in Chapter 5, to include the effects of shear deformations. Each member is divided into a finite number of discrete elements. Thus, any variation in member properties, loading or restraints may be represented. Each discrete element is subdivided into several layers to compute the discrete element stiffness and fixed end matrices, derived in Chapters 3 and 4. Subdivision helps to include variation in geometric properties of the section and in stress at different levels across the depth of the section. Member loads and restraints are discretized to the member station points. Static loads can be applied anywhere in the frame, but dynamic loads must be applied only at the joints to simplify the dynamic analysis.

It is not economical to solve for member station and joint displacements simultaneously, since the procedure includes a large system of equations, that has a large bandwidth and requires large computer storage and time. Therefore, member and joint solutions are performed separately to reduce the computer cost. Individual members are solved separately using desired number of discrete elements to obtain member stiffness and fixed-end-force matrices. The relationships between member end displacements and joint displacements, presented in

Chapter 5, are used to obtain the above matrices in the structural coordinates. The transformed matrices are then assembled to form the overall structure stiffness and load matrices, to solve for either joint displacements or joint displacement increments depending on linear or nonlinear analysis.

Since member and joint solutions are performed separately, an iterative cycle for each member occurs within each iteration of the joint solution. The member ends are "held" at positions corresponding to the current joint displacements to obtain member solutions. Thus, the procedure updates the structure stiffness after each iteration, and adds any unbalance in equilibrium as a corrective load.

The dynamic analysis presented in this chapter is valid for a general coupled mass matrix. However, the program considers only a diagonal mass matrix, and ignores the inertia masses. If desired, the program could be easily modified to consider coupled mass matrices. Although mass and stiffness dependent viscous damping is used in the theory, only mass dependent damping is incorporated into the program FRAME82.

Joint equations are set up including the tributary masses and viscous damping to obtain the governing structure dynamic equations, whereas member equations are concerned only with the static equilibrium of the members. Numerical integration of the coupled equations of motion is carried out using constant average acceleration method. Iteration is performed within each time step until the equilibrium errors are within the specified tolerences. Equilibrium errors are applied as corrective loads in the subsequent iteration.

6.3 Dynamic Analysis

The governing frame (joint) differential equation of motion is derived herein (4, 10, 11, 30). At any instant of time t, an equation of dynamic equilibrium can be written as

$$\{F_I(t)\} + \{F_D(t)\} + \{F_S(t)\} = \{F(t)\} \tag{6.1}$$

in which F(t) is the nodal (joint) force vector; $F_I(t)$, $F_D(t)$, and $F_S(t)$ are the forces due to inertia, damping, and stiffness respectively. A short time Δt later the equation would be

$$\{F_I(t+\Delta t)\} + \{F_D(t+\Delta t)\} + \{F_S(t+\Delta t)\} = \{F(t+\Delta t)\} \tag{6.2}$$

Subtracting Eq. 6.1 from Eq. 6.2 yields the incremental form of the equation of motion at time t as

$$\{\Delta F_I(t)\} + \{\Delta F_D(t)\} + \{\Delta F_S(t)\} = \{\Delta F(t)\} \tag{6.3}$$

The incremental forces in this equation may be expressed as

$$\{\Delta F_I(t)\} = \{F_I(t+\Delta t) - F_I(t)\} = [M]\{\Delta \ddot{W}(t)\} \tag{6.4a}$$

$$\{\Delta F_D(t)\} = \{F_D(t+\Delta t) - F_D(t)\} = [C_T(t)]\{\Delta \dot{W}(t)\} \tag{6.4b}$$

$$\{\Delta F_S(t) = \{F_S(t+\Delta t) - F_S(t)\} = [K_T(t)]\{\Delta W(t)\} \tag{6.4c}$$

where [M] is the mass matrix that does not change with time, and $[C_T(t)]$ and $[K_T(t)]$ are the tangent damping and stiffness matrices. The elements of the incremental damping and stiffness matrices are influence coefficients $C_{Tij}(t)$ and $K_{Tij}(t)$, and are given by

$$C_{Tij} = \frac{\partial F_{Di}}{\partial \dot{W}_j} \tag{6.5a}$$

$$K_{Tij} = \frac{\partial F_{Si}}{\partial W_j} \tag{6.5b}$$

When Eqs. 6.4 are substituted into Eq. 3, the incremental equation of motion becomes

$$[M]\{\Delta\ddot{W}(t)\}+[C_T(t)]\{\Delta\dot{W}(t)\}+[K_T(t)]\{\Delta W(t)\} = \{\Delta F(t)\} \tag{6.6}$$

Rewriting Eq. 6.6 for a time step j leads to

$$[M]\{\Delta\ddot{W}\}_j + [C_T]_j\{\Delta\dot{W}\}_j + [K_T]_j \{\Delta W\}_j = \{\Delta F\}_j \tag{6.7}$$

It is to be reminded that Eq. 6.7 is an approximate equation because of the use of initial tangent values for damping and stiffness terms.

The constant average acceleration method is used to solve the incremental differential Eq. 6.7. The basic equations for this method are presented in Appendix B. It is assumed that viscous damping results from a combination of mass dependent and stiffness dependent effects, so that

$$[C_T] = \alpha[M] + \beta[K_T] \tag{6.8}$$

in which α and β are constants to be chosen depending on the damping characteristics of the structure.

Using the equations given in Appendix B to relate incremental acceleration and velocity with incremental displacement, Eq. 6.7 can be written as

$$[M]\{-2\ddot{W}_j - \frac{4}{\Delta t}\dot{W}_j + \frac{4}{\Delta t^2}\Delta W\} + [\alpha[M]+\beta[K_T]_j]\{-2\dot{W}_j + \frac{2}{\Delta t}\Delta W\}$$
$$+ [K_T]_j\{\Delta W\} = \{\Delta F\}_j$$

i.e.

$$[(\frac{4}{\Delta t^2} + \frac{2\alpha}{\Delta t})[M] + (\frac{2\beta}{\Delta t} + 1)[K_T]_j]\{\Delta W\}_j =$$
$$\{\Delta F\}_j + [M]\{2\ddot{W}_j + \frac{4}{\Delta t}\dot{W}_j + 2\alpha\dot{W}_j\} + 2\beta[K_T]_j\{\dot{W}\}_j \tag{6.9}$$

Equation 6.9 can therefore be written as

$$[\gamma[M]+[K_T]_j]\{\Delta\bar{W}\}_j = \{\Delta F\}_j+[M]\{2\ddot{W}_j+\frac{4}{\Delta t}\dot{W}_j+2\alpha\dot{W}_j-2\beta\gamma\dot{W}_j\} \tag{6.10}$$

i.e.

$$\{\Delta\bar{W}\}_j=[\gamma[M]+[K_T]_j]^{-1}\{\{\Delta F\}_j+[M]\{2\ddot{W}_j+(\frac{4}{\Delta t}+2\alpha-2\beta\gamma)\dot{W}_j\}\} \tag{6.11}$$

where $\gamma = (\frac{4}{\Delta t^2} + \frac{2\alpha}{\Delta t}) / (\frac{2\beta}{\Delta t} + 1)$ (6.12)

and $$\{\Delta W\}_j = \frac{1}{\frac{2\beta}{\Delta t}+1} \{\Delta \bar{W}_j + 2\beta \dot{W}_j\} \tag{6.13}$$

Once $\{\Delta \bar{W}\}_j$ has been determined by Eq. 6.11, the increment of nodal displacement $\{\Delta W\}_j$ follows from Eq. 6.13, and the incremental velocity and acceleration follow from Eqs. B.5 and B.6 respectively.

6.4 Dynamic Equilibrium Check

Due to nonlinear nature of the response, unbalance forces may exist at any joint after predicting $\{\Delta W\}_j$ and computing the inertia, damping and member forces corresponding to the new displacement $\{W\}_{j+1}$. These unbalanced forces or "equilibrium" errors should be successively corrected until they are within specified tolerance in order to predict displacements, velocities, and accelerations for the next time step.

The dynamic equilibrium error $\{E\}_{j+1}$ at the j+1 th time station results from the lack of satisfaction of equations of motion. Thus, from Eq. 6.2

$$\{E\}_{j+1} = \{F\}_{j+1} - \{F_I\}_{j+1} - \{F_S\}_{j+1} - \{F_D\}_{j+1} \tag{6.14}$$

All the components on the right hand side of Eq. 6.14 can be exactly computed except $\{F_D\}_{j+1}$ which is the damping force. However, it can be calculated to a fairly reasonable accuracy by integrating the following tensor equation:

$$dF_{Di} = \frac{\partial F_{Di}}{\partial \dot{W}_j} d\dot{W}_j \tag{6.15}$$

In matrix notation the above equation can be written as

$$\{dF_D\} = [C_T] \{d\dot{W}\} \tag{6.16}$$

Therefore,

$$\{F_D\}_{j+1} = \{F_D\}_j + \int_{t_j}^{t_{j+1}} [C_T]\{d\dot{W}\} \tag{6.17}$$

To evaluate the integral in Eq. 6.17 use the average value over the time interval for $[C_T]$. In other words, a parabolic distribution is assumed for damping force within a time step. Then Eq. 6.17 becomes as

$$\{F_D\}_{j+1} = \{F_D\}_j + \frac{1}{2}\,[\alpha[M] + \beta[K]_j + \alpha[M] + \beta[K]_{j+1}]\{\Delta\dot{W}\} \tag{6.18a}$$

i.e.

$$\{F_D\}_{j+1} = \{F_D\}_j + [\alpha[M] + \frac{\beta}{2}[[K]_j + [K]_{j+1}]]\{\dot{W}-\dot{W}_j\} \tag{6.18b}$$

where $\{\dot{W}\}$ is the current value of the predicted velocity vector.

The dynamic equilibrium error $\{E\}_{j+1}$ can be considered as an additional force not absorbed by the system. If this error is applied to the system before proceeding to the next time step, then

$$\{\Delta\bar{W}\}_j = [\gamma[M] + [K_T]]^{-1}\{E\}_{j+1} \tag{6.19a}$$

i.e.

$$\{\Delta W\}_j = \frac{1}{\frac{2\beta}{\Delta t}+1}\,[\gamma[M] + [K_T]]^{-1}\{E\}_{j+1} \tag{6.19b}$$

where $[K_T]$ varies during the time step. This $\{\Delta W\}_j$ has to be added to the previous estimate of $\{W\}_{j+1}$. This displacement increment of $\{\Delta W\}_j$ will also cause increments in velocities and accelerations, and they are given in Eqs. 6.20 and 6.21:

$$\{\Delta\dot{W}\}_j = \frac{2}{\Delta t}\,\{\Delta W\}_j \tag{6.20}$$

$$\{\Delta\ddot{W}\}_j = \frac{4}{\Delta t^2}\,\{\Delta W\}_j \tag{6.21}$$

The above equations are obtained by omitting the terms $\{\dot{W}\}_j$ and $\{\ddot{W}\}_j$ in Equations B.5 and B.6, since their contributions have already been included in the first iteration.

Now the latest estimate of displacements, velocities, and accelerations can be computed and checked for the dynamic equilibrium again. If the dynamic equilibrium errors from Eq. 6.14 are sufficiently small, then the solution proceeds to the next time step. Otherwise, it is necessary to perform more iterations within the time step.

6.5 Damping Constants

The following procedure can be used to select the damping constants α and β. The relationship between generalized damping c_n, and frequency ω_n, of a linear elastic structure is given by (4, 10)

$$[C_n] = \alpha[M_n] + \beta[K_n] \tag{6.22}$$

in which, suffix n dentoes the nth mode and

$$[C_n] = [2\xi_n \omega_n M_n] \tag{6.23a}$$

and

$$[K_n] = [M_n \omega_n^2] \tag{6.23b}$$

where ξ_n= a proportion of critical damping in the n th mode. In view of Eqs. 6.23, Eq. 6.22 can be written as

$$\xi_n = \frac{1}{2}[\frac{\alpha}{\omega_n} + \beta\omega_n] \tag{6.24}$$

The advantage of this definition of damping should be apparent, because it clearly shows that stiffness dependent damping is more effective in the higher modes, whereas mass dependent damping controls the motion in the lower modes. The damping constants α and β can be defined in terms of proportion of critical damping ξ, and circular frequency ω, at two differnent modes as expressed below.

$$\alpha = \frac{2\omega_i \omega_j (\xi_i \omega_j - \xi_j \omega_i)}{(\omega_j^2 - \omega_i^2)} \tag{6.25}$$

$$\beta = \frac{2(\xi_j \omega_j - \xi_i \omega_i)}{(\omega_j^2 - \omega_i^2)} \tag{6.26}$$

For practical analysis, ω and ξ may be obtained for two different modes corresponding to the elastic structure and then values of α and β can be determined from Eqs. 6.25 and 6.26.

6.6 Comparison with Other Methods

In the above described method, the tangent value of damping is assumed as a linear combination of mass and tangent stiffness matrices. The damping force is then obtained by integrating the tangent damping matrix with respect to velocity vector. A parabolic distribution is assumed within a time step to evaluate the integration.

Kanaan and Powell (30) also assumed the damping matrix as a linear combination of mass and tangent stiffness matrices. But they assumed the incremental damping force as $[C_T]\{\Delta\dot{W}\}$, which is not necessarily true in the case of nonlinear structures. It is true only for linear elastic and nonlinear structures with tangent damping independent of stiffness. The preceeding statement is justified by Eqs. 6.27 defined below:

$$\{\Delta F_c\} = [C_T]\ \{\Delta\dot{W}\} + [\Delta C_T]\ \{\dot{W}\} \tag{6.27a}$$

i.e.

$$\{\Delta F_c\} = [C_T]\ \{\Delta\dot{W}\} + \beta[\Delta K_T]\ \{\dot{W}\} \tag{6.27b}$$

The procedure adopted by Kanaan and Powell did not include the second component on the right hand side of Eq. 6.27b. This means an additional load equivalent to $\beta[\Delta K_T]\{\dot{W}\}$ was permitted to act on the structure, which may significantly modify the resulting response of the structure. Therefore, an equal and opposite load of

magnitude $-\beta[\Delta K_T]\{\dot{W}\}$ must be applied as a corrective load during the subsequent time step. The analysis described herein includes the contribution due to change in stiffness while evaluating the damping force by Eq. 3.18b during each iteration. It is also to be pointed out that their analysis used neither dynamic equilibrium check nor iteration within a time step.

6.7 Comment on Static Analysis

The solution for static analysis utilized exactly the same procedure that is outlined for the dynamic analysis. However, the absence of damping and inertia terms in the static equlibrium equations simplify the analysis and procedure is explained in Section 4.7 under tangent stiffness method.

CHAPTER 7

THE COMPUTER PROGRAM FRAME82

7.0 Introduction

The computer program FRAME82 is developed for the inelastic analysis of plane frames under static and dynamic loadings and is subjected to the restraints outlined in Chapter 6. It is the latest enhanced version of the earlier programs FRAME63 of Santhanam (47) and FRAME53 of Hays (22). In addition to the important features such as nonlinear geometry, inelastic material, and member and joint supports, and cyclic loading available in FRAME63, FRAME82 includes member and joint shear deformations and mass dependent damping. The program is written in FORTRAN IV language for the IMB 370 Computer. Minor modifications may be needed to install this program on a different system.

Input Guide for FRAME82 and the required JCL statements to perform FRAME82 analysis on an IBM 370 system are given in Appendices C and D, respectively. Appendix E contains a glossary of the FORTRAN variables used in the program FRAME82, and is followed by a complete listing of the program in Appendix F. Several comment statements are inserted in the program to facilitate the understanding of the program logic. Sample inputs and a sample output are listed in Appendices G and H, respectively.

7.1 Main Features and Limitations of FRAME82

1. Dimensions: The program is presently dimensioned to analyze a frame of 25 joints, 50 members, 20 cross sections, 20 elements per member, etc. The MAIN program of FRAME82 consists of a dimension guide to make modifications in the dimensions of the program.

2. Discrete Element Model Type: Either shear or flexural discrete element models can be specified for each member. Shear model includes the effects of member shear deformations, that is ignored by the flexural model, in the member stiffness matrix formulation.

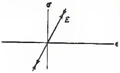
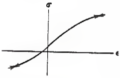
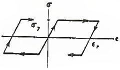
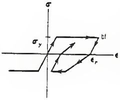
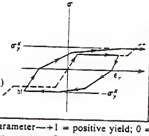
3. Number of Discrete Elements: User can specify different number of elements for each member, depending on its length and loading conditions, to obtain the desired accuracy. Almost double the number of shear elements are required to obtain the same accuracy for flexural response as of flexural analysis. This point is discussed in detail in Chapter 8. The number of elements for each member must be between four and twenty.

4. PDNO option: Usage of PDNO option ignores P-Δ and P-y moments and a completely linear geometric analysis is performed.

5. JSYES option: This sets the program to incorporate the effects of joint shear deformations in the analysis. Since the joint model was developed only for a rectangular joint, this option can be specified only for rectangular frames.

6. Member Flexural Stress-Strain Models: The flexural stress-strain behavior can be prescribed to be linear elastic, nonlinear elastic, Masing inelasticity, Masing inelasticity with stiffness degradation or special model for mild steel, as listed in Table 7.1. Flexural discrete element model is verified for all the above described

Table 7.1 Stress-Strain Models (48)

Type and $\sigma-\epsilon$ path (1)		Degradation factor, α (2)	Yield growth factor, β (3)	Memory Parameters: For each component (4)	Memory Parameters: For first component (5)
Linear elastic		—	—	—	—
Nonlinear elastic		—	—	—	—
Masing component		0.0	0.0	ϵ_r, ϵ_{rt}	region[a], reversal[b]
Degradation component (proposed)		$0 \leq \alpha \leq 1$ ($\alpha = 0$, Ref. 21) ($\alpha = 1$, Ref. 5)	0.0	ϵ_r, ϵ_{rt}, ϵ_{hfur}, ϵ_{hft}, E_{hf}, E_{hft}	region, reversal, ϵ_{max}, ϵ_{min}, $\epsilon_{previous}$
				Only One Component	
Special model for mild steel (proposed)		$\alpha \neq 0$ (suggested range is 0.15–0.30)	$\beta \neq 0$ (suggested range is 0.3–0.6)	ϵ_r, ϵ_{rt}, ϵ_{hf}, ϵ_{hft}, E_{hf}, E_{hft}	region, reversal, ϵ_{max}, ϵ_{min}, $\epsilon_{previous}$, σ_y^{grown}, σ_{yt}^{grown}

[a] Region parameter—+1 = positive yield; 0 = elastic; −1 = negative yield—all first component.
[b] Reversal parameter—0 = no; 1 = yes.
Note: All subscripts with t (e.g., ϵ_{rt}) refer to temporary values used in intermediate iterations of an analysis.

five types of stress-strain models. However, the shear discrete element model is verified only for the first three, namely, linear elastic, nonlinear elastic, and Masing inelasticity stress-strain models.

7. Member Shear: Input modulus of rigidity and specify discrete shear element model, for a member type to include member shear deformations into the analysis. The program considers only the linear elastic shear deformations.

8. Joint Stress-Strain Curves: The analytical joint model considers only the joint shear deformations and neglects flexural and axial deformations. Linear elastic or inelastic of Masing type can be prescribed for the joint shear stress-strain curve. Thus, any of the joint shear models described in Chapter 5 may be used in the analysis.

9. Joint and Member Supports: Either linear elastic or Masing inelastic stress-strain curves can be specified for joint and member supports.

10. Viscous Damping: Mass dependent damping can be prescribed to include viscous damping in the dynamic analysis.

11. Analysis Restart Feature: Provisions are available to pick up the results at a particular loading stage and proceed the analysis from that stage. This enables the user to break an analysis of a structure that would take a huge computational time, into several runs, and also helps the user to reduce time and load increments in the vicinity of load reversal regions where ill-condition exists for the stiffness matrices. The input guide of Appendic C explains the details for performing continuation runs.

12. Automatic Load Reduction of Static Loads: In case of a solution failure, automatic load reduction feature allows the program to reduce the static joint and member loads by specified percentages and to start a fresh analysis from the last available good solution. User must prescribe the number of such load reductions. Provision is also available to prevent any decrease or increase on the desired member loads, for specified members.

13. Automatic Time Step Reductions: This feature permits the program to reduce the time step by multiple of halves in the event of a dynamic analysis failure. Number of time step reductions must be input by the user.

14. Output options: The program output options are available for joint displacements and reactions, member responses, and joint equilibrium errors. These options provide the opportunity for the user to suppress any unwanted results during static analysis. However, during dynamic analysis, these options are used to specifiy the time steps at which the results need to be printed.

15. Joint Output: Joint displacements and reactions are printed at the end of each static load increment and at the requested time intervals for the dynamic analysis. Along with these results, shear panel internal moments are printed for rectangular frames that include joint shear deformations into the analysis.

16. Member Output: Besides the member displacements and forces at the member stations (connections of discrete elements), strains (axial and curvatures at both hinges for flexural model; axial, shear, and curvature at the hinge for shear model) are listed against the respective forces along the directions of the deformed geometry, at the hinges of the discrete elements.

17. MEMBER and PRINT options: MEMBER option gives the member results for monitor members at each stage of the iteration processes. PRINT option lists the upper triangular stiffness, and load matrices for all the members and joints respectively in the local and global coordinate systems, in addition to the details given by the MEMBER option. Since these options produce a large amount of output, users are advised to request these options only when indepth details are needed to locate the source of error for convergent difficulties.

18. Hysteresis Record: Hysteresis records of monitor members and joints are listed at the end of each dynamic run. Program allows to specify a maximum of 20 monitor members and joints. Member hysteresis includes the forces and displacements along the directions of original geometry at the member ends, and strains and the respective generalized forces along the directions of deformed geometry at the hinges next to member ends. Joint hysteresis includes joint displacements and shear moments, and plots displaying the variation of these parameters with time.

19. SAVE option: This requests the program to save member and joint hysteresis records in either direct access storage devices (disks) or magnetic tapes depending on the Job Control Statements. Member responses along directions of original geometry and undeformed geometry, and joint responses can be stored in three different storage devices. The stored output can be used to plot the results of the entire dynamic analysis of the structure.

20. Displacement Controlled Analysis: Displacement of a node (joint) can be controlled by inputting a very large spring stiffness with a corresponding very large force at the joint, with magnitude of

the stiffness not exceeding 10^{20}. A magnitude greater than 10^{20} would cause excessive underflow that might interrupt the execution.

21. General Comments:

(a) FRAME82 and FRAME63 were both written for IBM 370. FRAME82 is compiled with Fortran H Extended Compiler with Optimization Level at 3, whereas FRAME63 was compiled with Fortran G Compiler. Note that Fortran H Extended Compiler with Optimization Level 3 produces a load module that requires half of the execution time needed for the load module obtained by Fortran G Compiler to perform an analysis. The available FRAME63 program needs minor modifications to work on Fortran H Extented Compiler.

(b) Subroutine FSUB1 of FRAME63 calls subroutines FSUB21 and FSUB22 the number of times equivalent to the order of the system of linear equations to be solved, to obtain stiffness and load matrices for joints and member respectively. In FRAME82, the above referred subroutines are modified so that FSUB21 and FSUB22 are called just once by FSUB1 for a system of equations. This modification made considerable saving (10-15%) in the computational time. FRAME82 uses a new subroutine FSUB23 to provide the stiffness and load matrices for joint solutions that include JSYES option.

7.2 Program Structure

The program consists of a number of "basic" subroutines which perform independent operations that are generally called by the main program numerous times. Basic subroutines are available to read and print the structure geometry data, member and joint stiffness and loading data; to trace inelastic behavior of the materials; to form discrete element stiffness matrices for flexural and shear models; to

form member stiffness and load matrices; to assemble the global stiffness and load matrices; to solve and print the member and joint responses, etc. Subroutine STATIC for static analysis, DYNA for dynamic analysis with no JSYES option and DYNAJS for dynamic analysis with JSYES option are the major subroutines in this program. STATIC calls several subroutines to carry out the static analysis of a frame. It also calls subroutines DYNA and DYNAJS after reading the structure data to perform dynamic analysis. Main program calls only subroutine STATIC to carry out the necessary operations and also has the COMMON statements for the variables defined in the COMMON blocks.

The program employs four temporary and six permanent, direct access storage devices to perform a complete analysis of a structure. The temporary units store information of member stiffness and load matrices, and member supports during intermediate and final iterations. Three of the permanent files store the results pertaining to joints, joint supports and joint shear panels, and also the final results of all the member related information explained above. The program reads the last available good member and joint solutions including history dependent parameters from these permanent files during continuation runs. Hysteresis records of monitor members and joints are written in the other three permanent files. Appendix D gives descriptions and functions of these units with the space requirements. It also contains a list of job control statements required to execute FRAME82.

CHAPTER 8

VERIFICATIONS WITH ANALYTICAL SOLUTIONS

8.0 Introduction

This chapter is primarily intended to provide several example problems to test and verify the various features and options, such as Discrete Element Shear Model, joint shear, damping, etc., which are added to FRAME63 to develop FRAME82. The examples considered herein are either cantilevered members or single story one bay frames, which have closed form mathematical solutions for most of the examples. The obtained results are compared with FRAME63 analysis and other available studies.

Example 8.1 demonstrates how well the discrete element shear model predicts the response and the convergence rate with the number of elements in a member. The influence of shear on the buckling load and the post-buckling response of the column is illustrated in Example 8.2. Example 8.3 shows how damping influences the structural response. The hysteresis behavior of the joint shear panel is investigated in Example 8.4 using a cantilevered beam excited with a dynamic load. The influence of member shear and joint shear on a prismatic frame is studied in Example 8.5. All the features available in FRAME82 are utilized in the dynamic analysis of a frame subjected to 1.5 El Centro earthquake in Example 8.6.

8.1 Example of Deep Prismatic Cantilevered Beam

A three-foot long cantilevered S12X31.8 steel beam is shown in Fig. 8.1 with its material and section properties (52). The beam is analyzed neglecting all large displacement effects (i.e. PDNO option on) and using a shear area factor of 1.0, for three different loading cases that are listed below. Also, linear elastic material response is assumed.

Case 1: A 22 kips concentrated end load with uniform beam dead weight of 2.65 lbs/in.

Case 2: 22 kips concentrated end load only.

Case 3: A uniform load of 614 lbs/in.

Both flexural and shear models are employed in the analysis. The beam is divided into 4, 8, 12, 16, and 20 elements in each loading case to study the convergence. The beam deflection at the free end is selected as a basis for comparison between analytical and closed form (theoretical) solutions.

The theoretical solutions were obtained using the elementary structural analysis formulae, as follows. The flexural deflection due to concentrated end load and uniformly distributed load are given by Eqs. 8.1a and 8.1b:

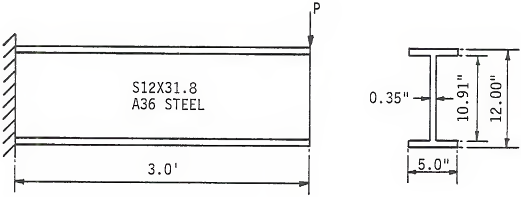
$$\delta_f = \frac{PL^3}{3EI} \tag{8.1a}$$

$$\delta_f = \frac{wL^4}{8EI} \tag{8.1b}$$

The shear deflection due to concentrated end load and uniformly distributed load are given by Eqs. 8.2a and 8.2b:

$$\delta_s = \frac{kPL}{A_s G} \tag{8.2a}$$

$$\delta_s = k \int_0^L \frac{wx}{A_s G}\, dx = \frac{k}{2} \frac{wL^2}{A_s G} \tag{8.2b}$$



$I = 218\ in^4$

$A = 9.35\ in^2$

$A_w = 3.82\ in^2$

$E = 29{,}000\ ksi$

$G = 11{,}200\ ksi$

$k = 1.0$

Figure 8.1 Cantilevered Prismatic Deep Beam

The principle of superposition is used to obtain the deflection for the case of combined concentrated end load and uniform load.

The solutions indicated in the tables as shear model and flexural type are obtained using the shear model but inputting a very high shear modulus such that the shear model would give the same results as the flexural model in the limit as the number of elements are increased. The results of each loading case are tabulated with theoretical solutions in Tables 8.1, 8.2, and 8.3 respectively.

Shear deformations account for approximately 25 percent of total deflection in Cases 1 and 2, and 30 percent in Case 3. It is to be noted that a deep beam (depth span ratio - 1/3) is chosen in this example to yield large shear deformations. It is seen from Tables 8.1 and 8.2 that the flexural model with n elements generally gives the same result as flexural type solution of the shear model with 2n elements. This is due to the fact that the flexural model has two flexural springs; whereas the shear model has one. However, in the case of uniformly distributed load, even four elements of the shear model predict the exact closed form value. It can easily be proven that a single shear model element will give the exact displacement for a beam under uniformly distributed load. Incidentally, it is noticed that the analytical results are equal to or lower than the theoretical values for all the cases other than flexural model case of the uniformly distributed load. The latter produces displacements larger than the exact value, i.e., it predicts upper bound displacement solution for uniformly distributed loading, while the other cases yield lower bound displacement solutions.

Table 8.1 Concentrated End Load with Self Weight

Model	Type	Displacements (X 0.01 in.)					
		Number of Elements					Theor.
		4	8	12	16	20	Solution
Shear	Total	7.191	7.255	7.267	7.271	7.273	7.276
	Flex.	5.336	5.400	5.411	5.415	5.417	5.421
Flex.	Total	5.400	5.416	5.418	5.419	5.420	5.421

Table 8.2 Concentrated End Load Only

Model	Type	Displacements (X 0.01 in.)					
		Number of Elements					Theor.
		4	8	12	16	20	Solution
Shear	Total	7.179	7.242	7.254	7.258	7.260	7.263
	Flex.	5.327	5.391	5.403	5.407	5.409	5.412
Flex.	Total	5.391	5.407	5.410	5.411	5.411	5.412

Table 8.3 Uniformly Distributed Load

Model	Type	Displacements (X 0.01 in.)					
		Number of Elements					Theor.
		4	8	12	16	20	Solution
Shear	Total	2.969	2.969	2.969	2.969	2.969	2.969
	Flex.	2.039	2.039	2.039	2.039	2.039	2.039
Flex.	Total	2.071	2.047	2.043	2.041	2.040	2.039

The computer solutions indicate close agreement with the theoretical values and the convergence is extremely good. The study indicates that 20-element shear model analysis is very close to convergence in all cases.

8.2 Example on Buckling of a Prismatic Cantilevered Beam

To investigate the influence of shear deformations on buckling load, a vertical prismatic cantilevered beam shown in Fig. 8.2 with its elastic properties is considered. In view of Equations 2.20 and 2.21, the Euler critical load P_E is

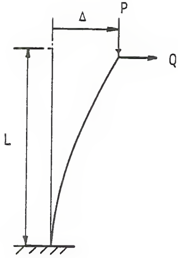
$$P_E = \frac{\pi^2 EI}{4L^2} = 181.7 \text{ kips}$$

and the critical load P_{cr} with shear deformations is

$$P_{cr} = P_E \left[1 + \frac{kP_E}{A_s G}\right] = 0.986P_E = 179.2 \text{ kips}$$

Twenty elements are used in both shear and flexural model analyses that include geometric nonlinearity. A shear area factor of 1.0 is used. A small lateral load $Q=0.001P_E$, is used in the analysis to disturb the column from an unstable equilibrium position. Three computer runs, two with shear model (true G and 10^5 times the actual G), and one with flexural model were made. As expected, flexural model and shear model with 10^5 times the G results coincide with each other. The nondimensional axial load P/P_E versus lateral displacement Δ/L curves of the flexural and shear model analyses are plotted in Fig. 8.3 along with theoretical solutions.

The theoretical solutions are obtained using the large displacement theory. Reference 53 gives the following relationships for a cantilevered beam considering only the flexural deformations:



$I = 25.4\ in^4$

$A = 5.43\ in^2$

$A_W = 1.13\ in^2$

$L = 100\ in$

$E = 29{,}000\ ksi$

$G = 11{,}200\ ksi$

$k = 1.0$

$$P_E = \frac{\pi^2 EI}{4L^2} = 181.7\ kips$$

Figure 8.2 Cantilevered Prismatic Column

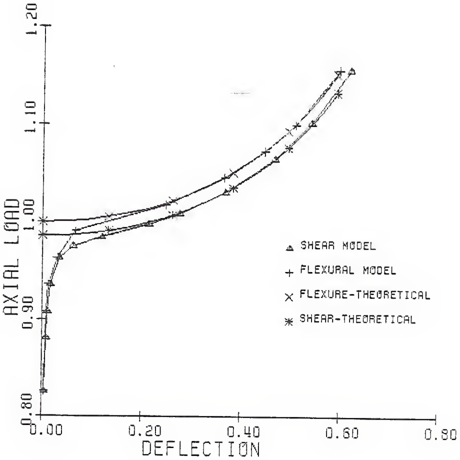


Figure 8.3 Nondimensional Axial Load — Displacement Curve

$$\beta L = K(p) \tag{8.3a}$$

$$\beta\Delta = 2p \tag{8.3b}$$

where

$$\beta = \left[\frac{P}{EI}\right]^{\frac{1}{2}} \tag{8.4a}$$

$$p = \sin\frac{\alpha}{2} \tag{8.4b}$$

in which α = the rotation of the free end from the original geometry, Δ = displacement of the free end, and $K(p)$ = complete elliptic integral of the first kind. Note that the Euler load is given in Eq. 2.21 as

$$P_E = \frac{\pi^2 EI}{4L^2} \tag{8.5}$$

In view of Eqs. 8.3 through 8.5

$$\frac{P}{P_E} = \frac{4K^2(p)}{\pi^2} \tag{8.6a}$$

$$\frac{\Delta}{L} = \frac{2p}{k(p)} \tag{8.6b}$$

When flexural and shear deformations are taken into account, the following relationships can be obtained:

$$\beta L = K(p) \tag{8.7a}$$

$$\beta\Delta = 2p \tag{8.7b}$$

where

$$\beta = \left[\frac{P}{EI\ (1 - \frac{KP}{A_s G})}\right]^{\frac{1}{2}} \tag{8.8a}$$

$$p = \sin\frac{\alpha}{2} \tag{8.8b}$$

Note that Eqs. 8.7a, 8.7b, and 8.8b are identical to Eqs. 8.3a, 8.3b, and 8.4b. The difference is only at the expression for β, and this difference can be easily recognized when one looks at Eq. 2.19. Equations 8.7 and 8.8 give the required relationships as

$$\frac{P}{P_E} = \frac{4K^2(p)}{\pi^2} \left[\frac{1}{1 + \frac{4K^2(p)}{\pi^2} \cdot \frac{P_E}{A_s G}} \right] \tag{8.9a}$$

$$\frac{\Delta}{L} = \frac{2p}{K(p)} \tag{8.9b}$$

The theoretical curves which are obtained from the above expressions using values of Elliptic Integrals tabulated in Ref. 7, coincide with the analytical curves for $\frac{\Delta}{L} > 0.20$. As expected, the shear model curve with true G yields more deflection than the flexural model curve for a given axial load. The effect of shear deformations on the solution is much less than in Example 8.1, since the depth span ratio of this example is about 1/20.

8.3 Example on Mass Dependent Damping

The cantilevered beam shown in Fig. 8.4 is considered to study the influence of mass dependent damping on the elastic and inelastic responses of a structure. The system is assumed to be under static equilibrium when a dynamic load of 70 kips is suddenly applied at the free end. Neither P-Δ nor P-y moments are included in the analysis, in order to compare the numerical results with the theoretical values. The weight of the beam is neglected for simplicity. The shear model with 20 elements is utilized in the analysis for all the following cases:

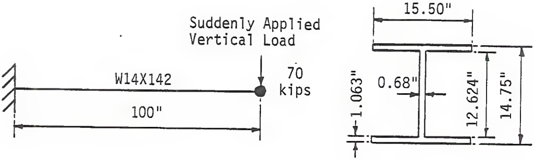
(i) Elasto-Plastic Analysis with no damping.

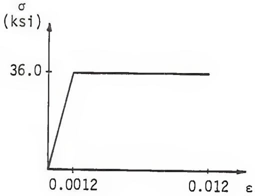
(ii) Elasto-Plastic Analysis with 5% damping.

(iii) Elastic Analysis with no damping.

(iv) Elastic Analysis with 5% damping.

The natural period of this one-degree system including shear deformations, is 0.2348. A time increment of 0.02 seconds is adequate to obtain maximum deflection with good accuracy. However, a time





$I = 1660.4 \text{ in}^4$

$A = 41.54 \text{ in}^2$

$A_w = 8.58 \text{ in}^2$

$E = 30{,}000 \text{ ksi}$

$G = 11{,}500 \text{ ksi}$

Figure 8.4 Cantilevered Beam Under Suddenly Applied End Load

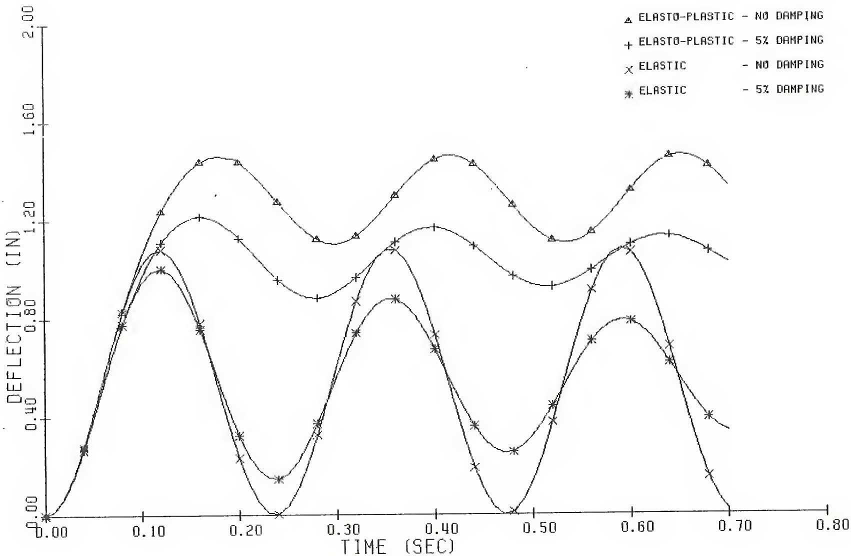


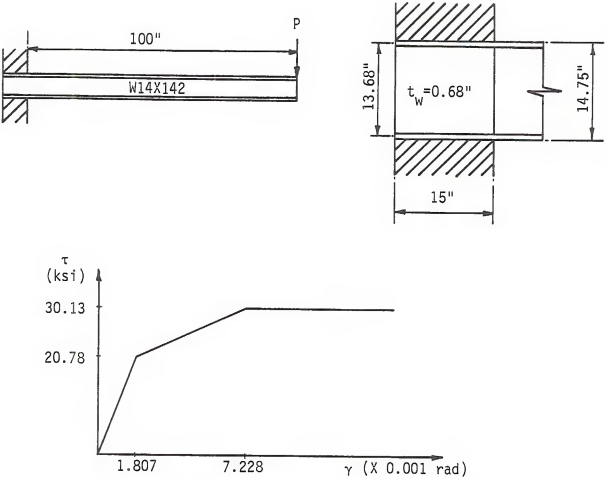
Figure 8.5 Deflection of Free End with Time

increment of 0.01 seconds is used in the dynamic analysis, to avoid any significant phase shift, that would make direct comparison with theoretical solutions difficult. Theoretical solutions available in Ref. 4, for elastic analyses with damping and no damping match well the numerical results.

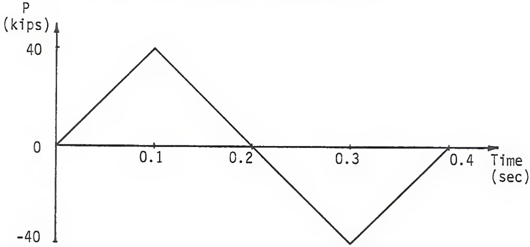
The computer results plotted in Fig. 8.5 illustrate the importance of material inelasticity and damping. Material inelasticity yields more deflection but reduces the amplitude of vibration. Damping diminishes the amplitude of vibration with time and the system ultimately reaches the steady state response or equilibrium position. Also, an effect of material inelasticity is that the equilibrium position is shifted due to inelastic unloading. The elastic solutions is only valid if the material remains elastic and this particular example would require that the yield stress be 62.2 ksi., which is 72.8 percent greater than the specified yield stress.

8.4 Example on Joint Shear Panel

To verify that the analytical model correctly follows the inelastic loading and unloading paths, the cantiliver of Fig. 8.4 is again considered and the shear panel dimensions are given in Fig. 8.6 (a) along with the shear stress-strain curve of the joint. The connection is assumed to prevent any "horizontal" rotation, but permits "vertical" rotation and, thus, the bending moment at the cantilevered end is carried by the joint panel. None of the available references give the shear stress-strain curve for a connection of this nature. A post-yield stiffness of 15 percent is assumed up to four times the yield shear strain for the shear stress-strain curve. A dynamic analysis is performed with no mass and the dynamic load in Fig. 8.6 (b), at the free

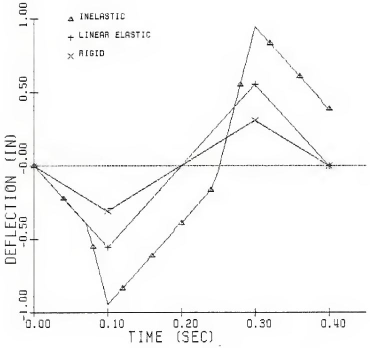


(a) Cantilever Beam with Connection Detail and Joint Shear Stress-Strain Curve

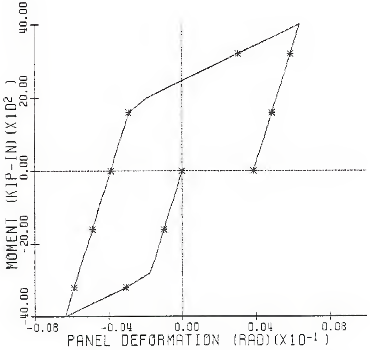


(b) Dynamic Load

Figure 8.6 Details for Joint Shear Panel Behavior Analysis



(a) Deflection of Free End with Time



(b) Shear Panel Moment versus Distortion

Figure 8.7 Cyclic Behavior of Joint Shear Panel and Cantilever Free End

end. Hence, the loading is essentially a gradually applied cyclic static load. The loading curve is chosen such that all points in the beam outside the joint remain elastic throughout the analysis. The beam is analyzed with prismatic properties, linear geometry option and 20 elements. The following three cases are investigated:

(i) Inelastic joint shear deformation

(ii) Linearly elastic joint shear deformation

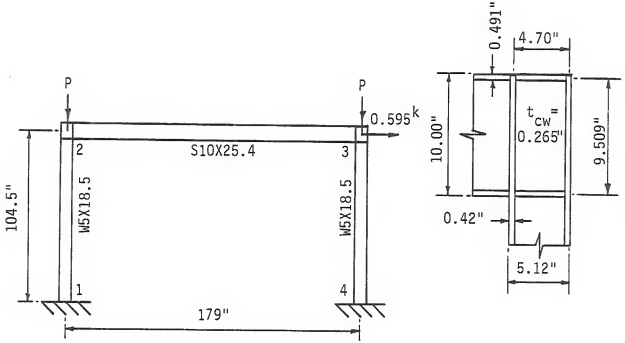
(iii) Rigid Joint

The deflection of the free end is plotted against time in Fig. 8.7 (a) for all three cases and hysteretic behavior of the joint shear panel is plotted in Fig. 8.7 (b). The computer results are exactly the same as the theoretical solutions. For the case of rigid joint, theoretical solution is obtained using Eq. 8.1a. The deflection produced by joint shear panel deformation, assuming Masing inelasticity, is added to the deflection obtained from Eq. 8.1a to get the theoretical deflection for the other two cases.

8.5 Example on Prismatic Frame Buckling

The frame in Fig. 8.8 with prismatic section and elastic properties, and connection details, is selected from Ref. 1 to study the member and joint shear effects on the buckling load. The buckling load for this frame considering flexural stiffness and negligible joint size is 594.8 kips (8). Monotonically increasing equal vertical loads are applied at joints 2 and 3, while a constant lateral load of 0.595 kips is applied to joint 3 to avoid any convergence problems with large column axial loads.

Joint shear deformations are considered at joints 2 and 3, and neglected at joints 1 and 4. The frame is analyzed with 12 and 20



SECTION	I (in^4)	A (in^2)	A_w (in^2)
W5X18.5	25.4	5.43	1.13
S10X25.4	12.4	7.46	2.80

E = 29,000 ksi
G = 11,200 ksi
k = 1.0

Figure 8.8 Prismatic Frame Buckling Analysis Data

elements for columns and beams, respectively, and a shear area factor of 1.0. The following four cases are studied:

(i) Elastic joints with discrete element shear model for members. (i.e., shear deformations considered in member and joint region)

(ii) Rigid joints with discrete element shear model for members. (i.e., no deformations within joint region)

(iii) Point joints with discrete elements shear model for members.

(iv) Point joints with discrete element flexural model.

The term Point joint refers to a joint that has negligible dimensions located at the intersection of the member centroidal axes. The vertical load increment is 40 kips up to 400 kips, 20 kips up to 520 kips, and 10 kips until the solution diverges.

The applied axial load is plotted against the horizontal deflection of joint 3, for all cases in Fig. 8.9. The analysis using Point joints with shear model exhibits a significantly lower buckling load than that of the flexural model analysis due to member shear deformations. Increased joint stiffness in the rigid joint with shear model analysis yields more resistant to buckling. However, the curves of Elastic and Point joints with shear model analyses almost coincide with each other. This could be explained as follows. Finite joint dimensions reduce the member lengths in the Elastic joint analysis. Even though joint shear deformations are included, axial and bending deformations are neglected over the joint shear panel. In the case of Point joints, members are longer and axial and bending deformations are included over the entire length; but, joint shear deformations are ignored. In the example problem, the joint shear deformations are almost equal to the additional axial and flexural deformations that is accounted for over

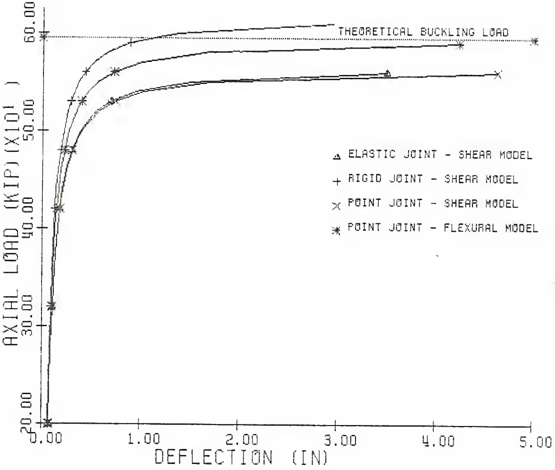


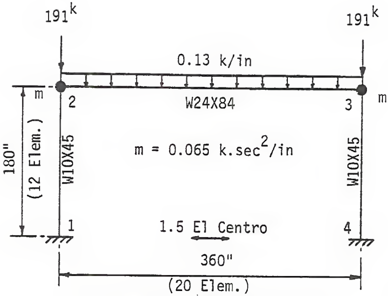
Figure 8.9 Axial Load versus Roof Displacement Curve

the shear panel length in the Point joint analysis. While it is clear that the use of a joint shear model is more rational than extending the flexural deformations arbitrarily into the joint region, it is good that models that do not consider the joint shear deformations may not be too much in error, if the joint regions are considered as part of the flexural members.

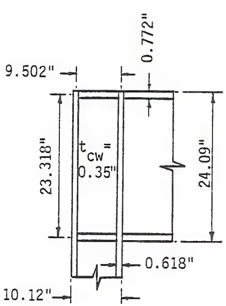
8.6 Single Story Frame Subjected to 1.5 El Centro Earthquake

A single story frame, analyzed by Latona (36) is selected to illustrate the application of FRAME82 to general inelastic analysis of a structure subjected to earthquake input. The frame and connection dimensions, gravity loads, section properties, and member stress-strain and joint shear stress-strain curves are given in Fig. 8.10. The post-yield stiffness parameter, recommended by Fielding and Chen (15), for corner joints is utilized to derive the joint shear stress-strain curve for the joints. Joint shear deformations are permitted only at the roof joints. The base of the columns are assumed to have Point joints with no shear deformations. The digital data of El Centro Earthquake available from Kanaan and Powell (30) are used as the input motion.

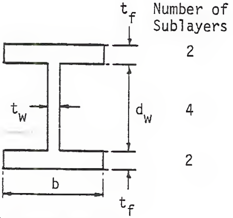
Latona (36) and Santhanam (47) used the weight of the girder and upper halves of the columns, to obtain the equivalent lumped mass at the roof joints. The heavy concentrated gravity loads acting at girder ends are not considered towards the contribution of the masses in this analysis in order to make comparison with the available results. Controlled acceleration method is used to simulate the ground acceleration of the earthquake. The desired acceleration input is achieved by employing a huge mass of 10^{20} at the base of each column, and premultiplying the input acceleration curve by the same factor



(a) Frame Dimensions and Loads



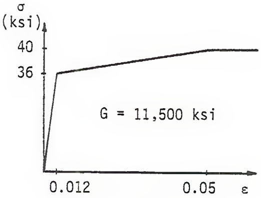
(b) Connection Dimensions



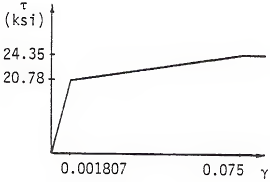
(c) Cross Section

dim (in)	Column	Beam
b	8.022	9.015
t_f	0.618	0.772
d_w	8.884	22.546
t_w	0.35	0.47

(d) Section Properties



(e) Member Stress-Strain Curve



(f) Joint Shear Stress-Strain Curve

Figure 8.10 Details for the Analysis of Latona's Frame

10^{20}. A time step of 0.02 seconds is found good enough to represent the earthquake input. The columns and beam are divided into 12 and 20 discrete elements; flanges and web in each element are divided into two and four sublayers, respectively.

The lateral displacement of the joint 2 relative to the base is plotted against time in Fig 8.11 for both shear and flexural model analyses. The flexural model analysis is exactly the same as of Santhanam's FRAME63 analysis. Shear model analysis yields more displacement than the flexural model analysis. However, the difference is not very significant in this particular example. This is due to joint shear panels being in the elastic region throughout the analysis, and the members being long compared to their depths. The shear moment versus panel distortion of joint 2 is plotted in Fig. 8.12. Since the shear panel yield moment is greater than the yield moments of the members, the shear panels at joints 2 and 3 remain in the elastic region. Figure 8.13 shows the time history of shear moment and moment at joint 2 for shear and flexural model analyses, respectively. The shear model analysis gives a slightly higher moment than the flexural model analysis. The rotations of fibers parallel to the global X and Y axes, in the joint shear panel 2 are plotted in Fig. 8.14 against the time. Since no joint effect is considered in the flexural model analysis, X and Y rotations are identical. It is interesting to observe that Y-rotation in the shear model analysis is very close to the rotation obtained in the flexural model anaysis. However, the X-rotation is much larger than the Y-rotation in the shear model analysis. Santhanam (47) has done an extensive comparison between FRAME63, CLOSE11 analyses and Latona's analysis. Figure 8.15 is

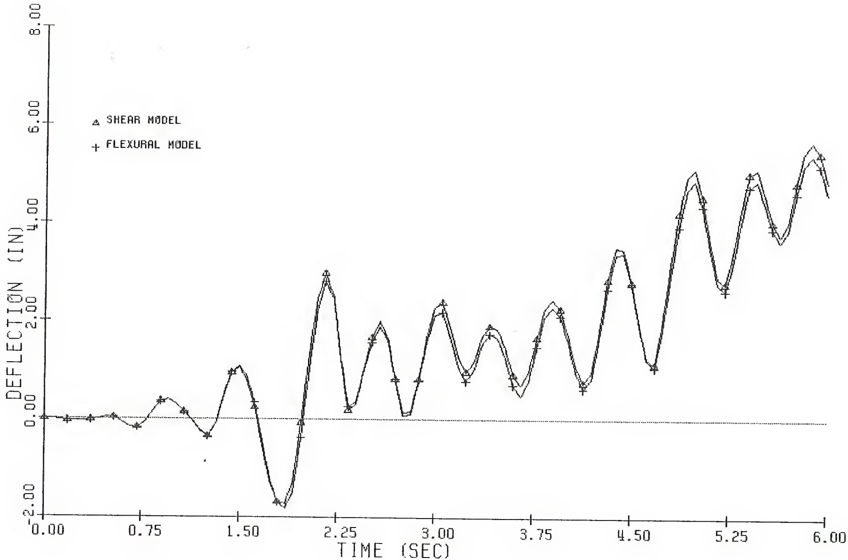


Figure 8.11 Lateral Displacement of Joint 2 with respect to the Base

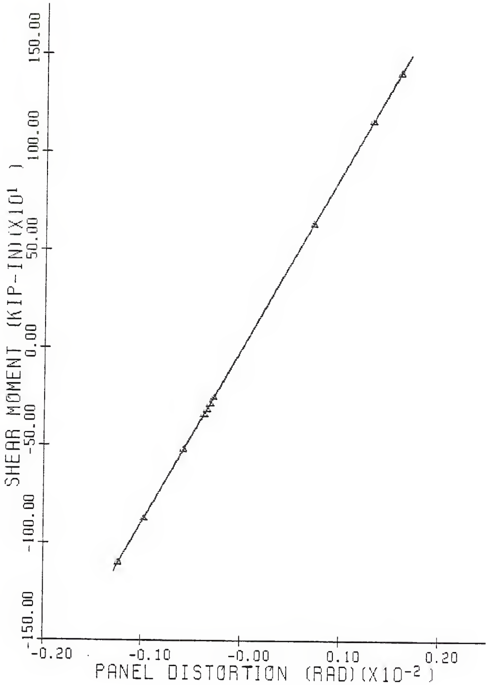


Figure 8.12 Shear Panel Moment — Distortion Diagram for Joint 2

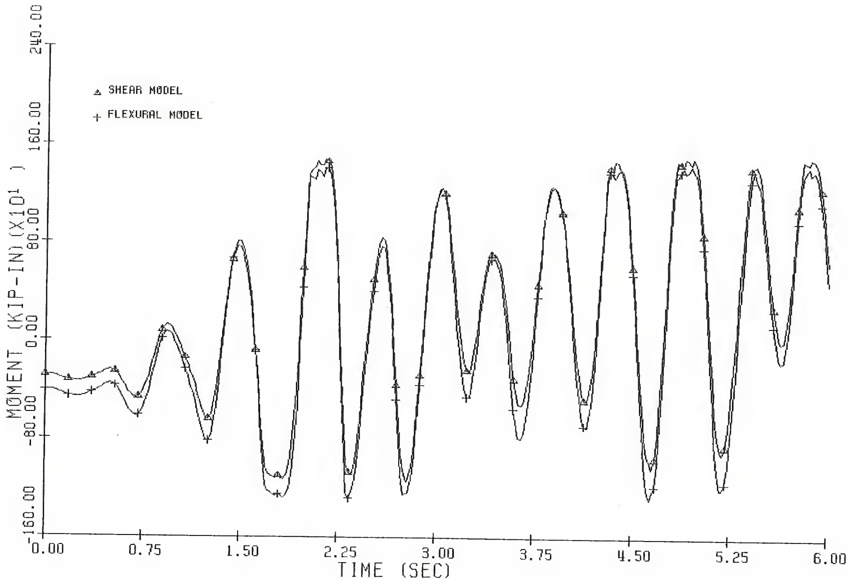


Figure 8.13 Time Histories of Shear Moment and Moment at Joint 2 for Shear and Flexural Model Analyses

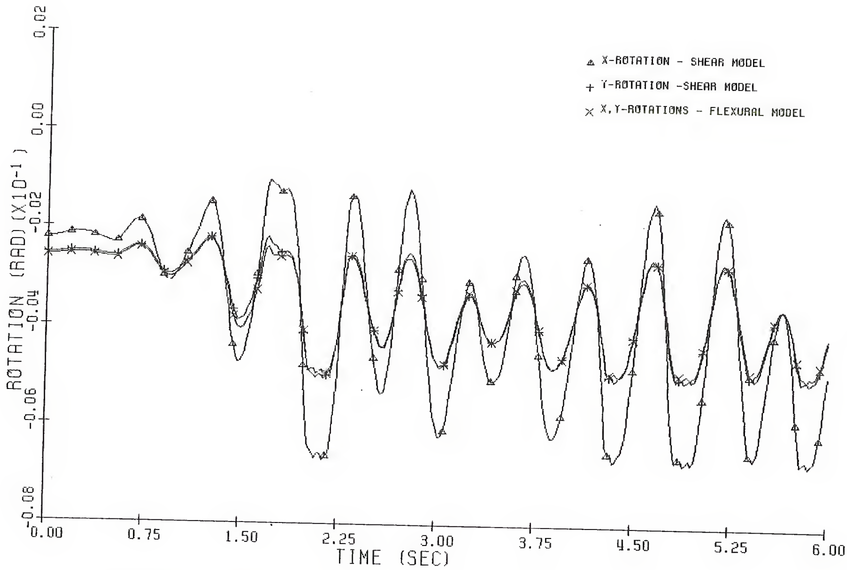


Figure 8.14 Rotations of x and y Axes of the Shear Panel at Joint 2 against Time

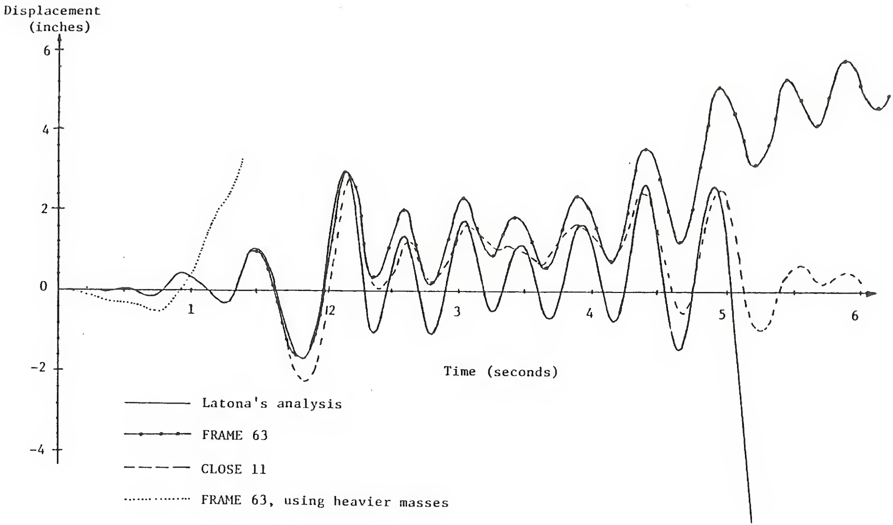


Figure 8.15 Lateral Relative Displacement of Joint 2 with respect to Base (47)

extracted from Ref. 47 to focus on the differences between each analysis.

Latona (36) divides the member into a number of control sections, and each control section into an assemblage of fibers to monitor stress and strain at each layer. The member stiffness matrix is obtained by integrating over each cross-section to obtain the flexibility coefficients, integrating over the length of the member to obtain the member flexibility matrix, and inverting the flexibility matrix. An ideal elasto-plastic stress-strain relationship is assumed for each fiber. The behavior of the structure between time increments is assumed to be linear; the incremental displacement is computed using stiffness matrices at current and preceeding time steps. Geometry of the structure is updated by adding the displacements that occurred during the preceding increment to the joint coordinates at the beginning of each increment. Thus, P-Δ moment is included and P-y moment is ignored. Correction for equilibrium error at the end of each time increment is neglected. Neither member shear nor joint shear is included in his analysis.

Santhanam's FRAME63 analysis is very similar to FRAME82 analysis, except it does not include member and joint shear deformations. The program CLOSE11 predicts the response of a closed coupled multiple degree freedom nonlinear elastic system using constant average acceleration method. This example was treated as a one degree of freedom in the CLOSE11 analysis. The nonlinear resistance-deformation input was obtained from the results of a series of static load analysis of the frame, using FRAME63.

It can be observed from Fig. 8.15 that the CLOSE11, FRAME63, and Latona's analyses give almost identical results up to 2.3 seconds. No significant deviation could be observed in this region due to the relatively small deformations. However, FRAME63 predicts much larger deformations and drift after 2.3 seconds. CLOSE11, FRAME63, and FRAME82 analyses are based on the same numerical integration scheme. The non-drifting nature of the results of CLOSE11 in the later periods of time indicate that the drift in the results of FRAME63 is primarily due to material and geometric nonlinearities. In view of these formulations, it can be concluded that the omission of P-y moments in Latona's analysis is the major factor that contributes to the deviation between FRAME63 and Latona's analyses.

Latona's dynamic analysis assumes lateral displacement of all joints at a given story level are identical and includes only lateral mode of vibration, i.e., rigid floor assumption is used. However, FRAME82 and FRAME63 analyses include both translational modes and neglect the inertia mass corresponding to rotational freedom. Figure 8.15 illustrates also the importance of including the heavy concentrated loads at joints 2 and 3 into joint masses.

CHAPTER 9

COMPARISONS WITH AVAILABLE EXPERIMENTAL DATA

9.0 Introduction

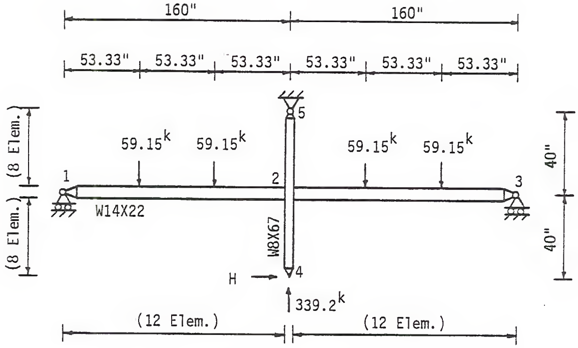
Two examples with experimental results available are presented in this chapter to compare with the FRAME82 analysis. All the experimental investigations were carried out in the Structural Engineering Laboratory of the University of California, Berkeley. Inelastic behavior of a beam-column subassemblage (33) is investigated in Example 9.1. The behavior of the joint shear panel is focused in this example. The dynamic analysis of the three story single bay frame reported in Ref. 12 is considered in Example 9.2. The structure is excited with a motion which is very similar to the El Centro Earthquake motion. The excitation was produced on the University of California, Berkeley, shaking table while attempting to simulate El Centro Earthquake. Digitized acceleration data from the University of California, Berkeley, were not available. Thus, the earthquake input graphs of Ref. 12 were digitized and used in the analysis.

9.1 Example of Beam-Column Subassemblage

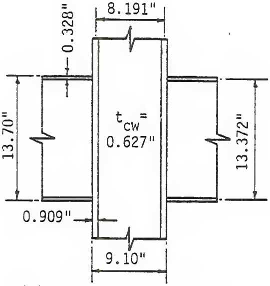
Bertero et al. (3) and KRAWINKLER et al. (33) carried out experimental investigation of the simplest structural assemblage, a column with two beams framing into it, to study the interaction between the basic structural elements (beams, columns, and connections) under repeated loading, when combined into subassemblages within a frame. Two types of subassemblages, one representing an upper story and the other a

lower story, were used to obtain a wide range of behavior that could be expected in subassemblages of high rise unbraced frames. Subassemblage A which represents a typical "upper story" has the following characteristics: Column is subjected to low axial load, while the beam end moment is primarily due to gravity loads, since the effect of the design lateral load is small. The flange and web of the column are thin and in general, horizontal stiffeners are required in the connection to prevent web crippling and column flange distortion. Subassemblage B which represents a typical "lower story" has the following properties: The column is subjected to high axial load and the contribution of gravity loads to the beam end moment is small compared to that of the lateral loads which generally govern the design. The flanges and web of the column are thick enough so that no horizontal stiffener is likely to be required in the connection, even though it is common practice to use one. In their experiment, horizontal stiffeners were used only for subassemblage A.

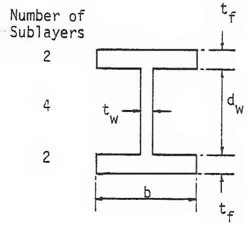
"Specimen B1" which is of the subassemblage B type is selected in the present analysis to compare with the FRAME82 results. The details of the test specimen B1 are given in Fig. 9.1. The beam ends 1 and 3 are supported by rollers, upper column end 5 is hinged and lower column end 4 is free. The structure is subjected to concentrated gravity loads of magnitude 59.15 kips at the middle third points of the beams, a constant vertical load of 339.2 kips at joint 4 and a cyclic horizontal load H at joint 4. The FRAME82 analysis includes the self-weight of the beams. The measured dimensions and material properties of the test specimen are used in the analysis.



(a) Idealized Subassemblage



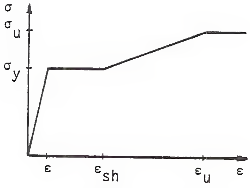
(b) Connection Dimensions



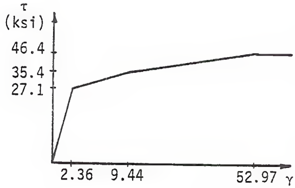
(c) Cross-Section

Member	b (in)	t_f (in)	d_w (in)	t_w (in)	w (k/in)
Column	8.16	0.909	7.282	0.627	0.0056
Beam	5.04	0.328	13.044	0.239	0.0018

(d) Section Properties



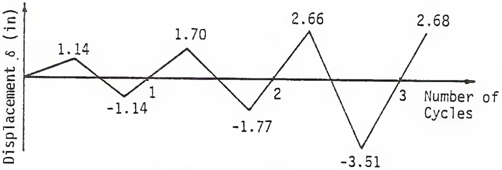
(e) Member σ-ε Curve



(f) Joint τ-γ Curve

	COLUMN W8X67		BEAM W14X22	
	web	flange	web	flange
ε_y (X 10^{-3})	1.58	1.43	1.54	1.28
ε_{sh} (X 10^{-3})	7.0	7.0	23.0	23.0
ε_u (X 10^{-3})	30.8	36.4	37.6	49.9
σ_y (ksi)	47.0	42.5	46.5	38.5
σ_{sh} (ksi)	47.0	42.5	46.5	38.5
σ_u (ksi)	66.0	66.0	56.0	56.0
E (ksi)	29,800	29,800	30,100	30,100
E_{sh} (ksi)	800	800	650	650
G (ksi)	11,460		11,580	

(g) Material Properties



(h) Loading Program

Figure 9.1 Details for Analysis of Beam-Column Subassemblage

The horizontal displacement of joint 4 is controlled during the analysis as in the case of the experiment. Figure 9.1 (h) shows the displacement controlled loading used in the analysis. In the experiment, each cycle shown in Fig. 9.1 (h) was repeated four times and it was observed that elastic unloading stiffness decreased with increasing column displacement. The present FRAME82 analysis does not include the stiffness degradation effects. Hence, one cycle is considered in the anallysis for every four cycles of the experiment to keep the computer cost low.

The joint shear stress-strain curve is derived as explained in Chapter 5. The τ-γ curve, Fig. 9.1 (f), is obtained by adding the contribution of column flanges to post yield shear stress, predicted by Krawinkler, to the theoretical shear stress-strain curve derived from the flexural stress-strain curve, Fig. 9.1 (e). However, the plateau in the shear stress-strain curve is neglected and the strain hardening region of the panel is obtained by linearly connecting the values of the stresses at the strains $4\gamma_y$ and γ_u. Masing model is used to include inelastic behavior of the material. The slowly applied static loading is simulated by a dynamic analysis with no mass at joint 4 to avoid unnecessary output and to reduce cpu time.

The horizontal load H versus the horizontal displacement δ of joint 4, and H versus the rotation θ_r of joint 2 are respectively plotted in Figures 9.2 and 9.3. One could observe that the analytical curves envelop the experimental curves in these diagrams. The deviation between the analytical and experimental curves is significant only in the region where load reversal occurs. This could be due to the usage of one load cycle in the analysis for four cycles that were used in the

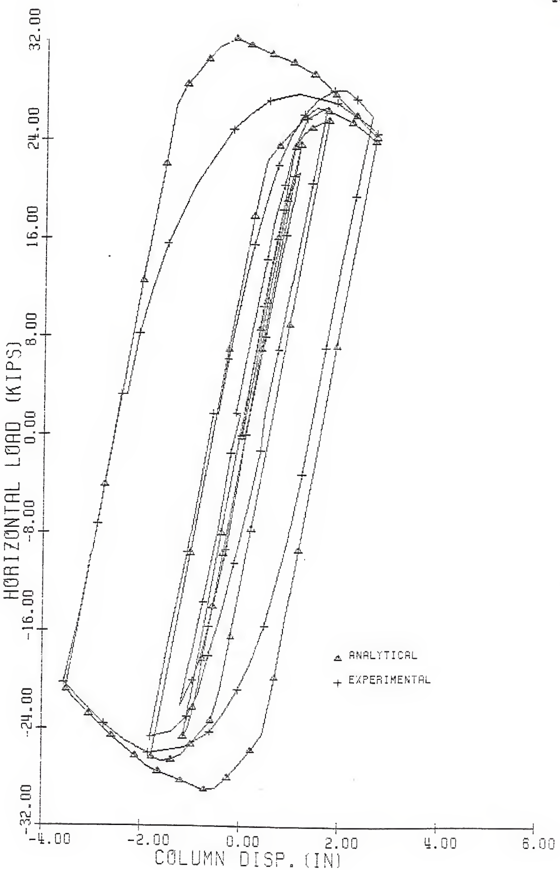


Figure 9.2 Horizontal Load H — Horizontal Displacement δ Diagram

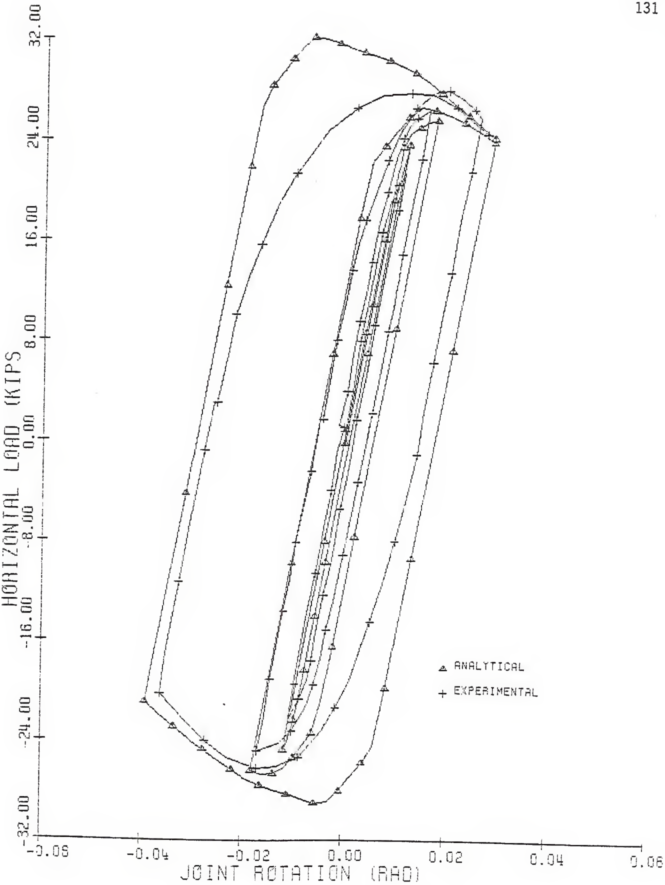


Figure 9.3 Horizontal Load H — Joint Rotation θ_r Diagram

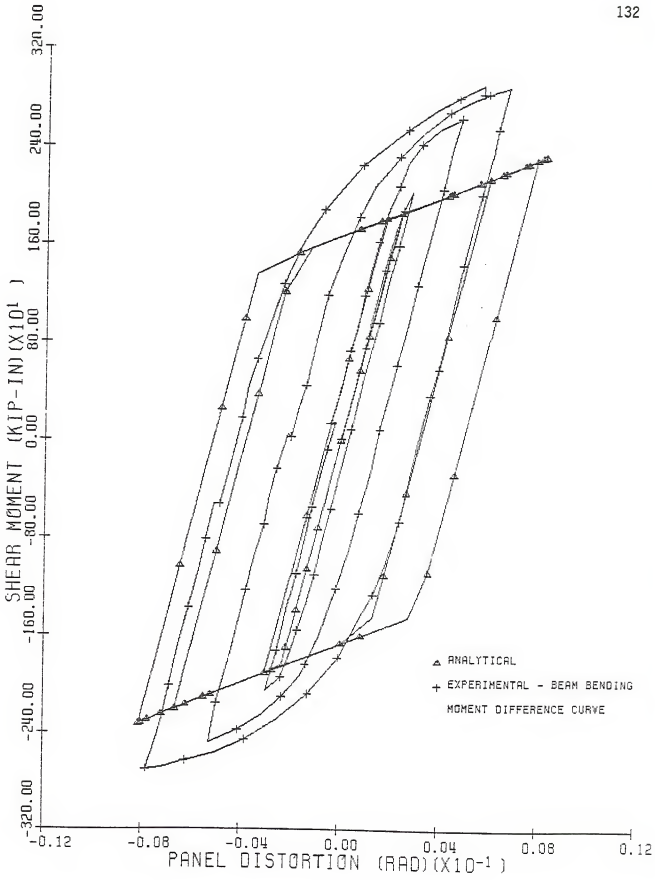


Figure 9.4 Joint Shear Moment — Joint Panel Distortion Diagram

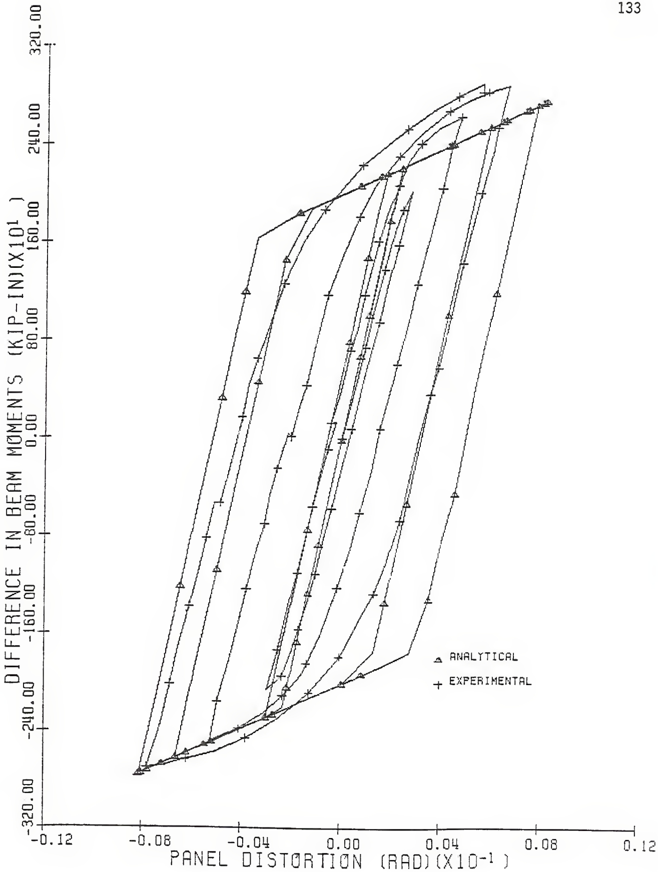
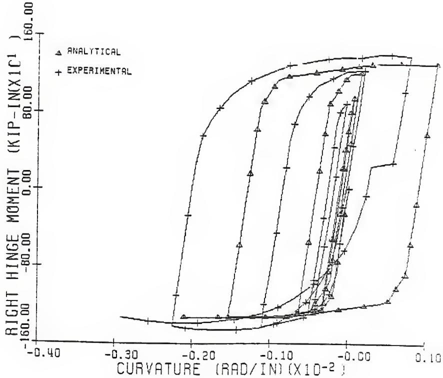
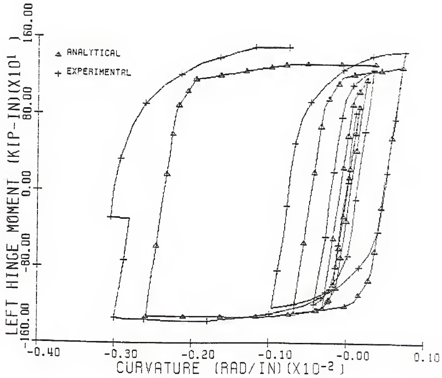


Figure 9.5 Difference of Beam End Moments — Joint Panel Distortion Diagram

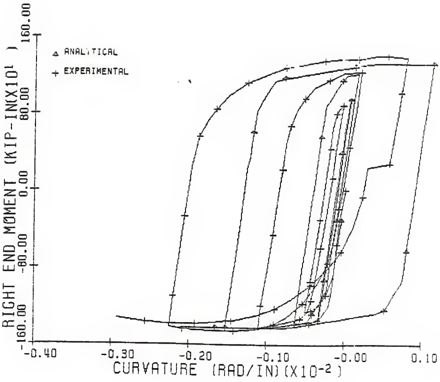


(a)

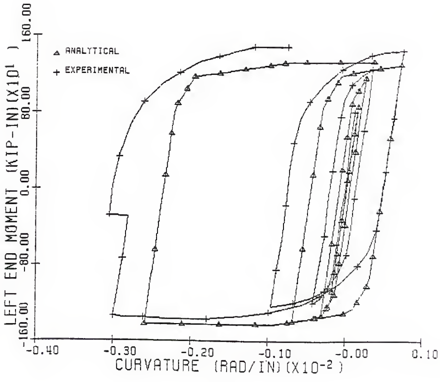


(b)

Figure 9.6 Moment — Curvature Diagrams at the Hinges closer to Joint 2



(a)



(b)

Figure 9.7 Beam End Moment — Curvature Diagrams at Joint 2

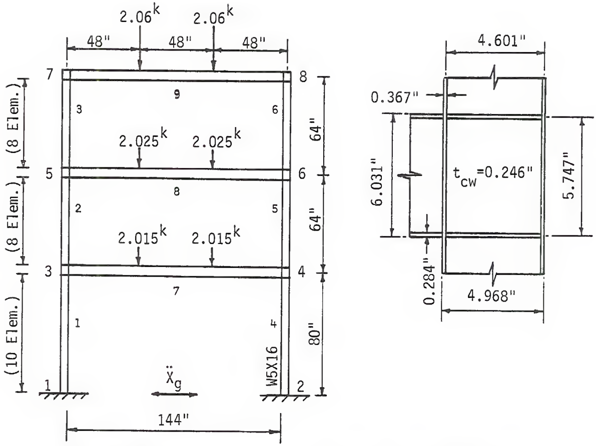
experiment for a chosen displacement range and also the inability of Masing model to predict the degradation behavior of structures accurately (21, 47, 48).

Joint shear panel moment is plotted against joint shear distortion in Fig. 9.4. Since no experimental joint shear moment data are available, difference of beam end moments at joint 2 is plotted instead of the joint shear moment for the experimental curve. Thus, a significant difference is noticed between the analytical and experimental curves of Fig. 9.4. The difference of beam end moments at joint 2 versus joint shear panel distortions is shown in Fig. 9.5. It shows good agreement between experimental and analytical results.

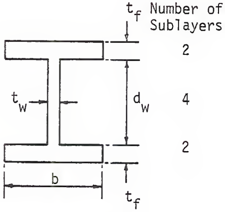
The bending moment and curvature of the beams at the discrete element hinges which are closer to joint 2 (6.5 inches away from the respective beam ends) are plotted in Fig. 9.6. However, the experimental curves correspond to beam end moments and the average curvatures over a beam length of 11 inches. Figure 9.7 gives the beam end moments versus the curvatures plots. The curvatures are defined as stated for the previous figure.

9.2 Example of a Three Story Frame

Clough and Tang (12, 13), and Tang and Clough (51) performed several dynamic tests on a three story steel frame to study the seismic behavior of a large-scale steel structure. The test structure shown in Fig. 9.8 (a) was excited on the 20 foot square earthquake simulator of the Earthquake Engineering Research Center, University of California, Berkeley. Two phases of tests were carried out to observe significant inelastic deformations in the structure. In the Phase I study, the joint panel zones of the structure were deliberately made understrength



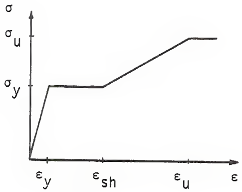
(a) Idealized 3 Story Frame and Typical Connection Detail



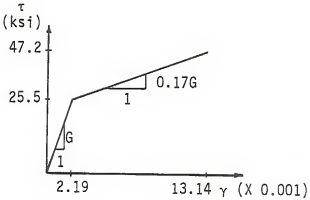
(b) Cross-Section

Dim (in)	Column	Beam
b	5.0	4.016
t_f	0.367	0.284
d_w	4.234	5.463
t_w	0.246	0.243

(c) Section Properties



(d) Member σ-ε Curve



(e) Joint τ-γ Curve

	COLUMN W5X16		BEAM W6X12	
	web	flange	web	flange
ε_y (X 10^{-3})	1.46	1.34	1.61	1.27
ε_{sh} (X 10^{-3})	27.0	19.7	24.5	15.2
ε_u (X 10^{-3})	70.5	59.1	61.2	48.4
σ_y (ksi)	44.1	39.8	49.6	39.2
σ_{sh} (ksi)	44.1	39.8	49.6	39.2
σ_u (ksi)	65.0	65.4	67.6	63.6
E (ksi)	30,300	29,800	30,900	30,800
E_{sh} (ksi)	480	650	490	735
G (ksi)	11,650	11,460	11,880	11,850

(f) Material Properties

	1st FLOOR	2nd FLOOR	3rd FLOOR
Point Load (kips)	2.015	2.025	2.06
Distributed Load (k/in)	0.00441	0.00426	0.00380
Mass (k.sec^2/in)	0.006011X2	0.006009X2	0.006017X2
Damping	0.147%		

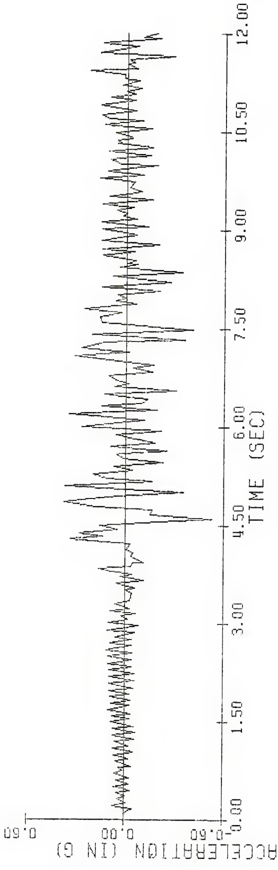
(g) Load, Mass, and Damping

Figure 9.8 Details for Analysis of 3 Story Frame

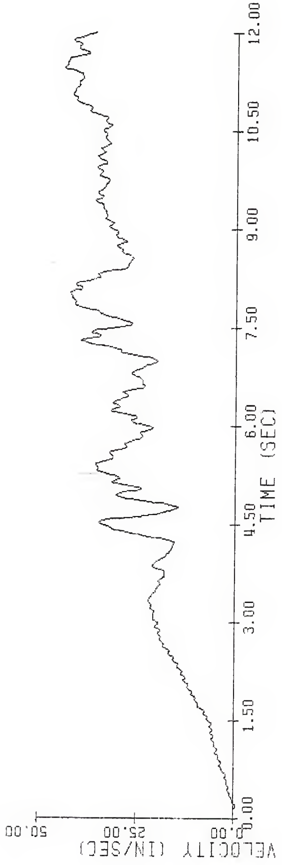
so that yielding was initiatied in these regions. In the Phase II study, the panel zones were strengthened with doubler plates, so that yielding occurred exclusively at column and beam ends. Several earthquake inputs are used in both Phase I and II structures.

The experimental results obtained for the test designated as EC400-I are compared with FRAME82 analysis in this study. Figure 9.8 shows the details of input of the test frame for the FRAME82 analysis. The bases of the frame are assumed to be rigid. Joint shear deformations are considered in the other joints. The members are discretized into finite number of elements as shown in Fig. 9.8 (a). Measured section and material properties are used in the analysis. The strain hardening stiffness of the joint shear stress-strain curve is taken as 0.17 times the modulus of rigidity, the experimentally observed value. Masing model option is used to incorporate material inelastic behavior. The tributary weight of the structural components is assumed as a uniformly distributed load over the girders. For the dynamic analysis, tributary mass of structural components and concentrated loads are lumped at the nodes. Joint masses are included in the equations of motion for structure along X and Y directions and rotational inertia is ignored.

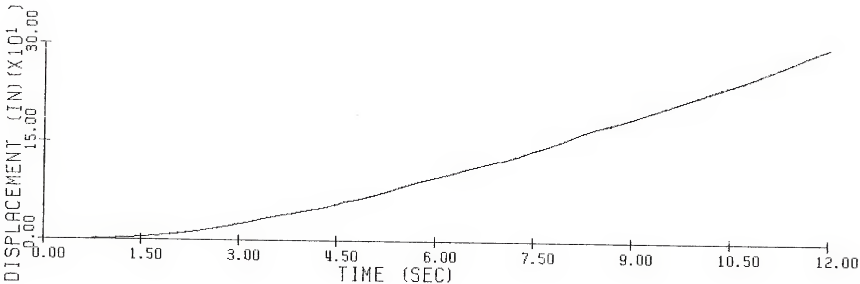
The graphical accelerogram of EC400-I, available in Ref. 12, is magnified by 380 percent in both acceleration and time axes directions, and then digitized using a Summagraphics TD48 electronic digitizer. Constant average acceleration method is employed to integrate the accelerogram to get velocity and displacement. The obtained acceleration data, and the velocities and displacements of the shaking table obtained by integration are plotted in Fig. 9.9 against time.


ACCELERATION (IN G)
-0.60
0.00
0.60
0.00
1.50
3.00
4.50
6.00
7.50
9.00
10.50
12.00
TIME (SEC)

(a)


VELOCITY (IN/SEC)
0.00
25.00
50.00
0.00
1.50
3.00
4.50
6.00
7.50
9.00
10.50
12.00
TIME (SEC)

(b)



(c)

Figure 9.9 Base Line Uncorrected Table Acceleration, Velocity, and Displacement — Time Diagrams

Digitized values need to be corrected to obtain the best possible integrated velocity and acceleration results. This is achieved by introducing corrections to the base line, such as to minimize the mean-squared table velocity (40). A seventh order base line correction curve is used in this example.

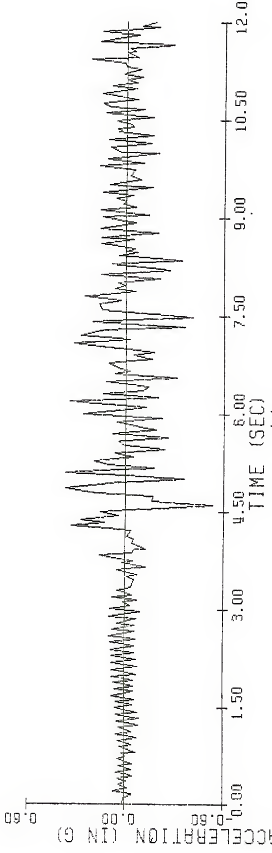
Mass proportional damping (β=0) corresponding to the forced vibration test results of 0.147 percent critical for the first mode of the structure is specified. The obtained frequency of the structure 2.273 cps for the first mode is used to calculate α:

$$c = \alpha m = \xi c_{cr} = 2\xi\sqrt{km}$$

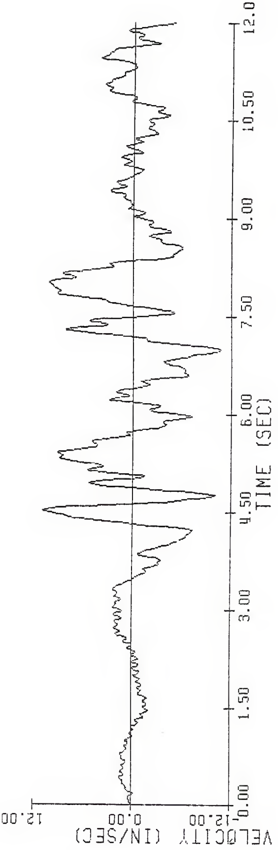
i.e. $$\alpha = 2\xi\left(\frac{k}{m}\right)^{\frac{1}{2}} = 2\xi\omega = \frac{2(0.147)2.273(2\pi)}{100} = 0.042$$

A time step of 0.012 seconds, approximately half the time interval of digitization for recorded data is used. This time interval is adequate to insure numerical stability since the period of vibration for the first mode had been estimated as 0.44 seconds.

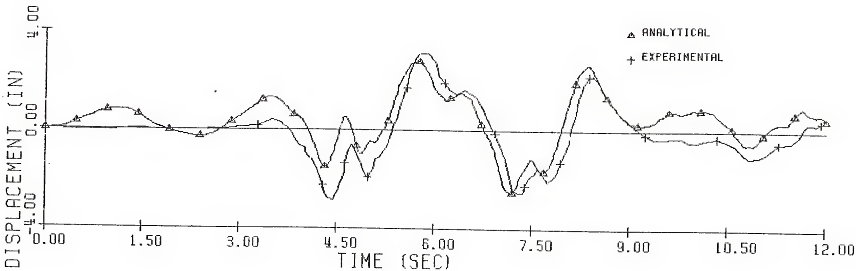
The results obtained in the FRAME82 analysis are presented herein along with the available experimental observations. Since the analytical results reported by Tang and Clough were matched with the experimental values by varying several parameters, such as damping, their analytical results are not reproduced. Figure 9.10 displays accelerations, velocities and displacements of the shaking table obtained respectively for base line corrected accelerograms. The observed shaking table displacement is plotted in Fig. 9.10 (c) and follows a pattern very similar to the analytical curve. Relative displacements of each story with repsect to table and absolute table displacement are shown in Fig. 9.11. Figure 9.12 displays story drifts against time. The experimental curves are advanced by 0.1 seconds in


ACCELERATION (IN G)
0.60
0.00
-0.60
0.00
1.50
3.00
4.50
6.00
7.50
9.00
10.50
12.00
TIME (SEC)

(a)

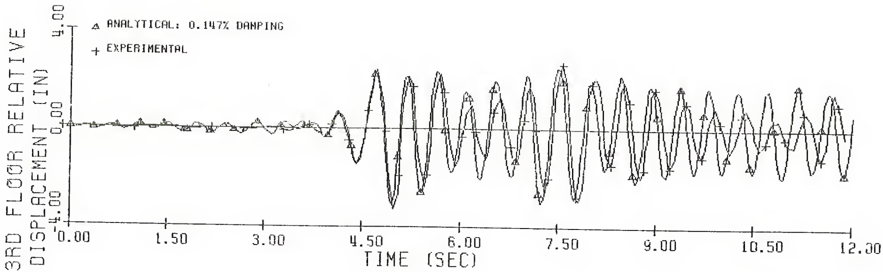

VELOCITY (IN/SEC)
12.00
0.00
-12.00
0.00
1.50
3.00
4.50
6.00
7.50
9.00
10.50
12.00
TIME (SEC)

(b)

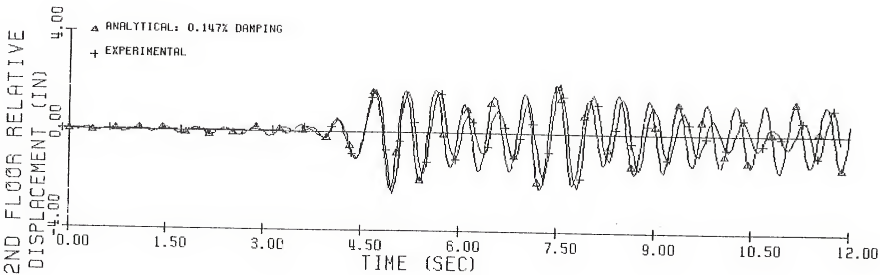


(c)

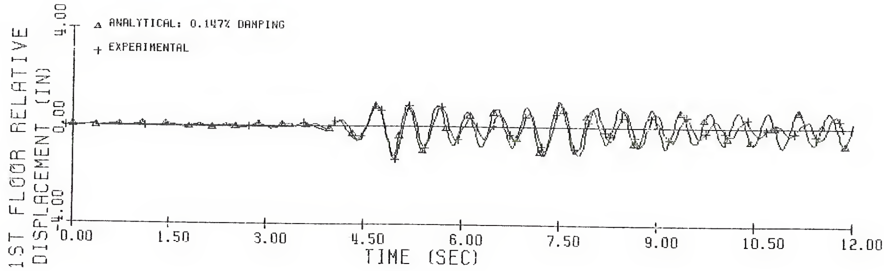
Figure 9.10 Base Line Corrected Table Acceleration, Velocity, and Displacement — Time Diagrams


ANALYTICAL: 0.147% DAMPING
EXPERIMENTAL
3RD FLOOR RELATIVE
DISPLACEMENT (IN)
4.00
0.00
-4.00
0.00
1.50
3.00
4.50
6.00
7.50
9.00
10.50
12.00
TIME (SEC)

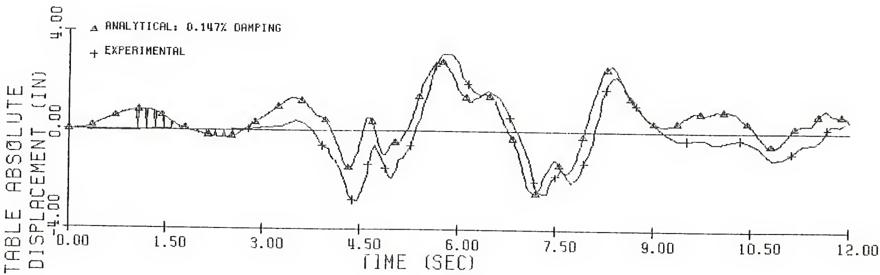
(a)


ANALYTICAL: 0.147% DAMPING
EXPERIMENTAL
2ND FLOOR RELATIVE
DISPLACEMENT (IN)
4.00
0.00
-4.00
0.00
1.50
3.00
4.50
6.00
7.50
9.00
10.50
12.00
TIME (SEC)

(b)

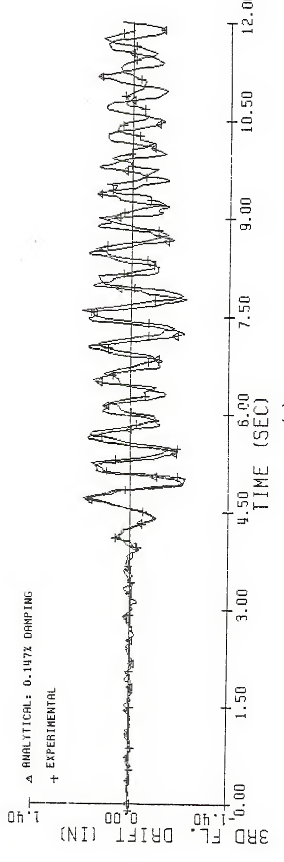


(c)

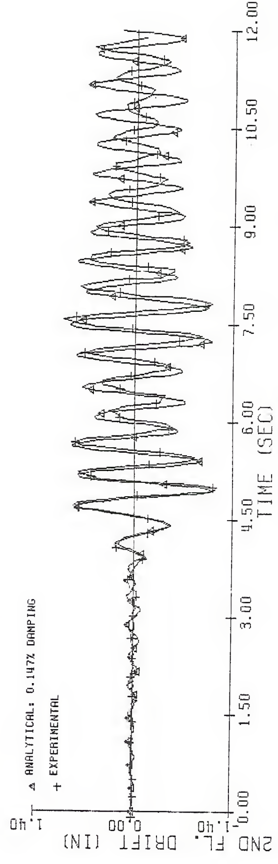


(d)

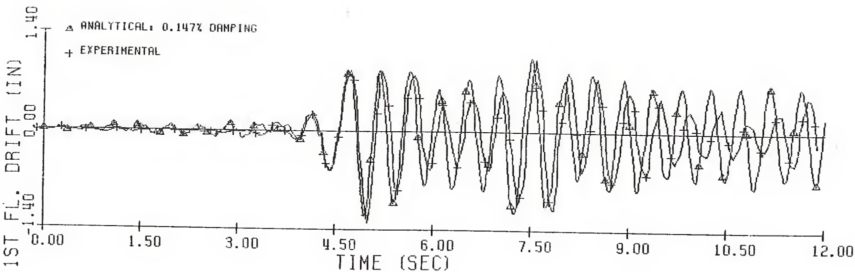
Figure 9.11 Time Histories of Relative Displacements of Floors with respect to Table and Absolute Table Displacement


ANALYTICAL: 0.147% DAMPING
EXPERIMENTAL
3RD FL. DRIFT (IN)
1.40
0.00
-1.40
0.00
1.50
3.00
4.50
6.00
7.50
9.00
10.50
12.00
TIME (SEC)

(a)


ANALYTICAL: 0.147% DAMPING
EXPERIMENTAL
2ND FL. DRIFT (IN)
1.40
0.00
-1.40
0.00
1.50
3.00
4.50
6.00
7.50
9.00
10.50
12.00
TIME (SEC)

(b)

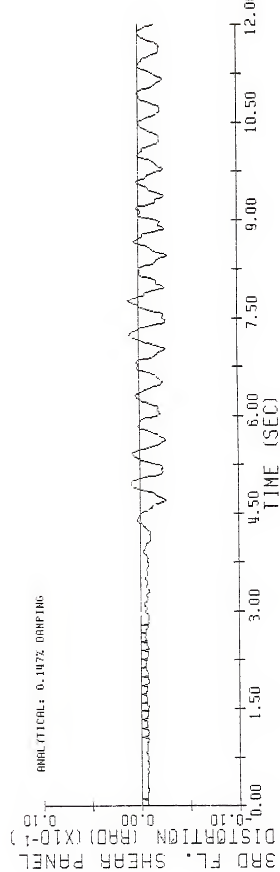


(c)

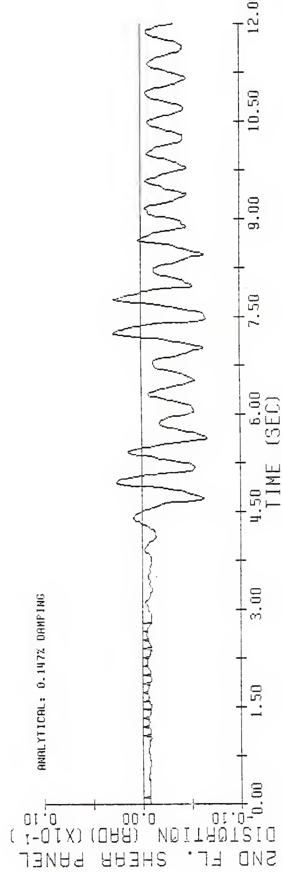
Figure 9.12 Floor Drift — Time Diagrams

the relative story displacement and story drift plots in order to match the first peak with the analytical results. The analytical distortions of the joint shear panels along the right column are plotted in Fig. 9.13 against time. The measured first floor joint shear panel distortion is also given in Fig. 9.13 (c). Figure 9.14 consists of the predicted hysteretic behavior of the joint shear panels along the right column. The respective experimental curves are not reproduced from Ref. 12 as it is difficult to digitize these complicated plots. Experimental curves display a smooth transition from elastic to inelastic region instead of the abrupt change exhibited in Fig. 9.14. However, they are generally in good agreement with the DRAIN 2D results. Figure 9.15 displays comparative plot of measured and predicted results for story shears. The analytical moments at the upper ends of the columns and girder ends for the first floor are plotted in Fig. 9.16. The measured moments are also plotted in Figs. 9.16 (c) and (d).

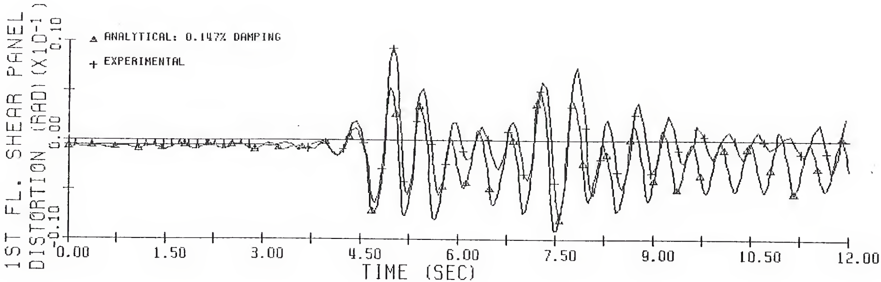
The analytical plots given in Ref. 13 and 51 were obtained using the program DRAIN 2D that was developed by Kanaan and Powell (30). DRAIN 2D considers three degrees of freedom, namely, horizontal, vertical, and rotational displacements. Provision is made for degrees of freedom to be deleted or combined (for zero and identical displacements at different nodes) to obtain substantial reduction in the computer time. The structure is assumed to be composed of the following elements; namely, (i) truss, (ii) beam-column, (iii) shear panel, and (iv) semi-rigid connection. All elements are assumed to have bilinear relationship between force and displacement. The interaction between axial force and moment may be specified in the beam-column element which is permitted to yield through the formation of concentrated plastic


3RD FL. SHEAR PANEL
DISTORTION (RAD)(X10-1)
0.10
0.00
-0.10
ANALYTICAL: 0.147% DAMPING
0.00
1.50
3.00
4.50
6.00
7.50
9.00
10.50
12.00
TIME (SEC)

(a)

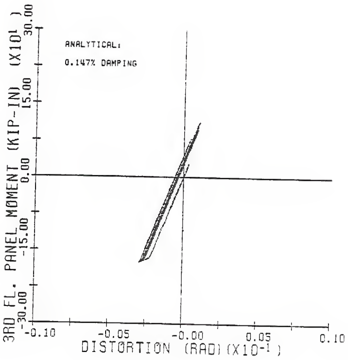

2ND FL. SHEAR PANEL
DISTORTION (RAD)(X10-1)
0.10
0.00
-0.10
ANALYTICAL: 0.147% DAMPING
0.00
1.50
3.00
4.50
6.00
7.50
9.00
10.50
12.00
TIME (SEC)

(b)

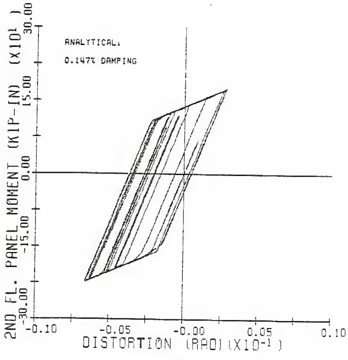


(c)

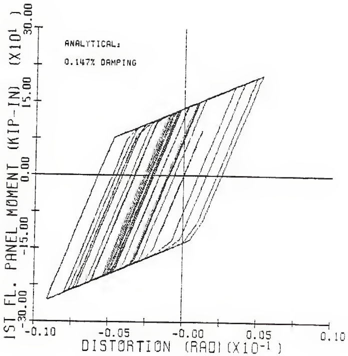
Figure 9.13 Joint Shear Panel Distortion — Time Diagrams


ANALYTICAL:
0.147% DAMPING
3RD FL. PANEL MOMENT (KIP-IN) (X10^{1})
30.00
15.00
0.00
-15.00
-30.00
-0.10
-0.05
-0.00
0.05
0.10
DISTORTION (RAD) (X10^{-1})

(a)

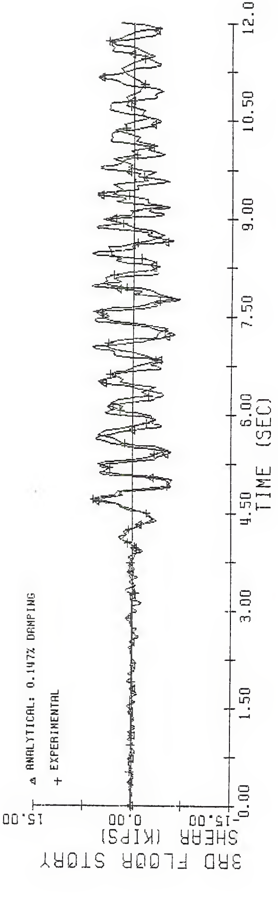

ANALYTICAL:
0.147% DAMPING
2ND FL. PANEL MOMENT (KIP-IN) (X10^{1})
30.00
15.00
0.00
-15.00
-30.00
-0.10
-0.05
-0.00
0.05
0.10
DISTORTION (RAD) (X10^{-1})

(b)

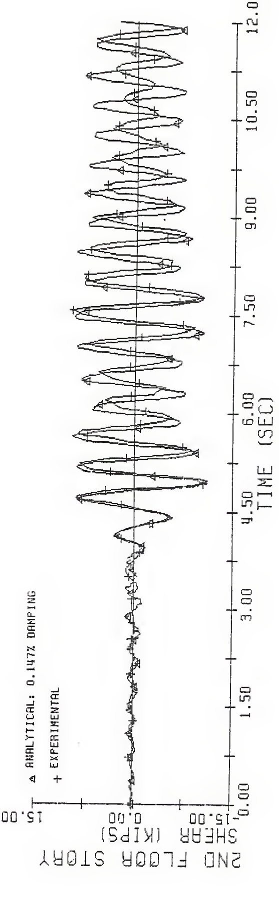


(c)

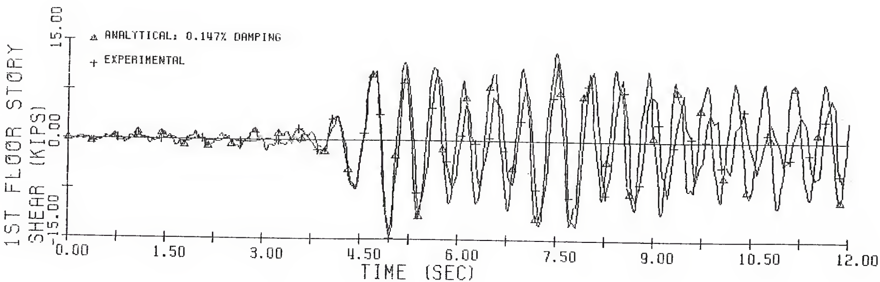
Figure 9.14 Joint Shear Panel Moment — Time Diagrams


3RD FLOOR STORY
SHEAR (KIPS)
15.00
0.00
-15.00
△ ANALYTICAL: 0.147% DAMPING
+ EXPERIMENTAL
0.00
1.50
3.00
4.50
6.00
7.50
9.00
10.50
12.00
TIME (SEC)

(a)

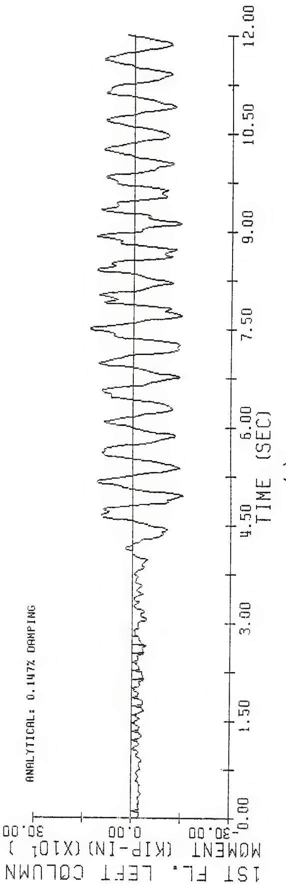

2ND FLOOR STORY
SHEAR (KIPS)
15.00
0.00
-15.00
△ ANALYTICAL: 0.147% DAMPING
+ EXPERIMENTAL
0.00
1.50
3.00
4.50
6.00
7.50
9.00
10.50
12.00
TIME (SEC)

(b)

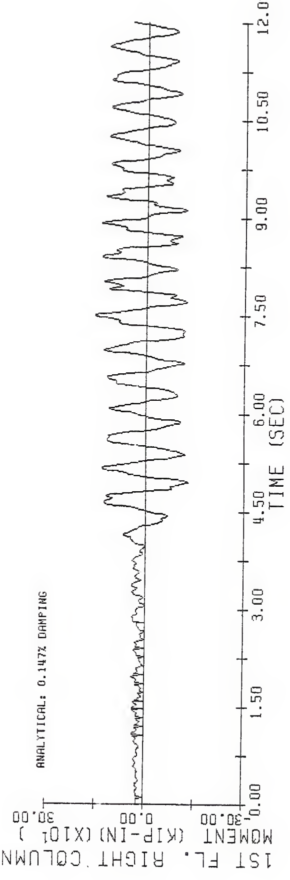


(c)

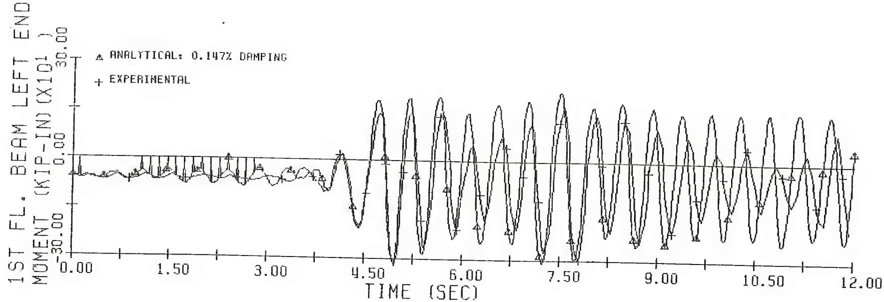
Figure 9.15 Story Shear Force — Time Diagrams


ANALYTICAL: 0.147% DAMPING
1ST FL. LEFT COLUMN
MOMENT (KIP-IN)(X10¹)
30.00
0.00
-30.00
0.00
1.50
3.00
4.50
6.00
7.50
9.00
10.50
12.00
TIME (SEC)

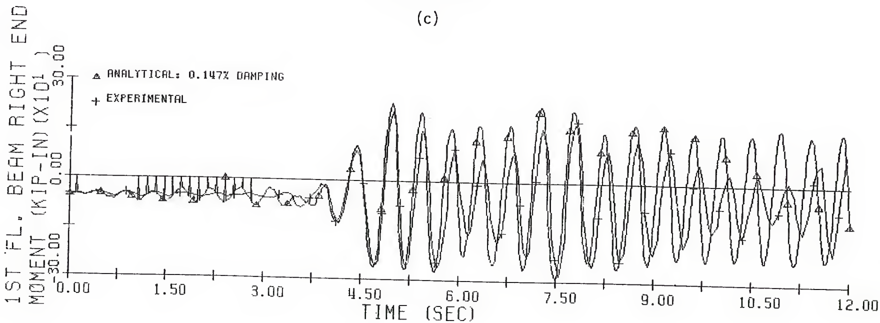
(a)


ANALYTICAL: 0.147% DAMPING
1ST FL. RIGHT COLUMN
MOMENT (KIP-IN)(X10¹)
30.00
0.00
-30.00
0.00
1.50
3.00
4.50
6.00
7.50
9.00
10.50
12.00
TIME (SEC)

(b)



(c)



(d)

Figure 9.16 Time Histories of First Floor Column and Girder Moments

hinges at it ends. Additional nodes can be specified along a member so that spread of yielding can be studied. Inelastic axial deformations are assumed not to occur in beam-column elements, because of the difficulty of considering the interaction between axial and flexural deformations after yield in their finite element model. The P-Δ moment effect is taken into account by including a geometric stiffness based on the axial force under static loads. The influence of P-y moment and member shear deformations on the structural response are ignored. Static loads may be applied prior to the dynamic loading, but no yielding is permitted under these loads. The dynamic response is determined by step-by-step integration with a constant acceleration assumption within any step. The tangent stiffness method is employed to get the inelastic response of a structure. The program assumes a linear structureal behavior within each time step. If the stiffness of the structure changes due to yielding or unloading within a time step, the stiffness matrix is recomputed at the end of that time step and the new stiffness matrix is used in the succeeding time step. Any unbalance in equilibrium resulting from a change in stiffness within a time step is eliminated by applying corrective loads in the subsequent time step. Diagonal mass matrix is utilized in the analysis. Viscous damping of mass-dependent and/or stiffness-dependent type may be specified.

Clough and Tang (13), and Tang and Clough (51) used the idealized structural Model C shown in Fig. 9.17 in their DRAIN 2D analysis. The frame was discretized as an assemblage of nine beam-column, six shear panel and two semi-rigid connection elements. The semi-rigid connections were at the column ends. Rocking mechanism of the shaking table supported by vertical actuators that could reduce the overall

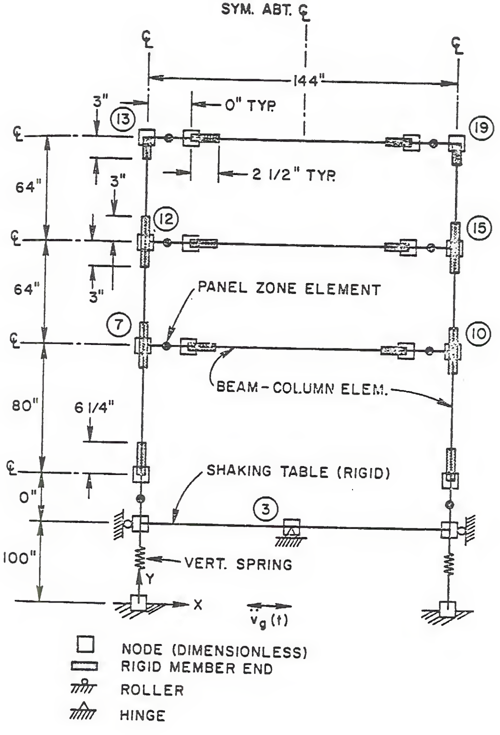


Figure 9.17 Shaking Table Structure Interaction Model Used by Clough and Tang (13)

stiffness of the structure, was modeled with two vertical springs. The table was restrained from vertical translation by a hinge at its center. The actual dimensions of the members, post-yield strain hardening ratio of 17 percent for the panel zones, a rotational stiffness of 750,000 kip-in/rad for each semi-rigid connection, a time step of 0.01204 seconds and mass dependent damping of 1.5 percent critical for the first mode were input. The stiffness of the vertical springs was varied to match the first mode frequency of the model with the experimental observation. The tributary mass of structural components and static loads was assumed to be lumped at the nodes for the motions in the X direction only. A parabolic base line correction was applied to the table acceleration records in order to obtain the best possible integrated displacement results.

Observations and Interpretations

The following observations and interpretations are made about the FRAME82 analysis, DRAIN 2D analysis, and experimental results.

(i) The FRAME82 analytical model yields a slightly higher period of vibration than the measured value. This, leads to phase shift which could be due to low damping, rigid base assumption, inadequate number of discrete elements per member, large time step, etc. It is to be pointed out that the pitching motion of the shaking table would have reduced the frequency of the structure.

(ii) The predicted and measured response amplitudes match at the first peak. However, the predicted response oscillates through a large amplitude, while the measured response damps out. The damping could be increased to obtain better amplitude and phase

correlations. The measured 0.147 percent critical damping for the first mode of the structure is used in this analysis. Tang used 1.5 percent critical damping, which is about ten times greater than the measured value in the program developed by Kanaan and Powell (30) to match the computed and mesured results in References 13 and 51.

(iii) The dead load and load history effects were disregarded in the experimental results available in Ref. 12. EC400-I is one among the several test runs performed on the Phase I structure. However, the predicted results include dead load effect. Even though FRAME82 is capable of including load history effect the present example does not include stresses due to previous loadings since the load history is not listed completely in Ref. 12. Moreover, the computer cost to include all prior load histories would be beyond the budget of this study. The plotted experimental curves for shear panel distortions and first floor column and girder moments are obtained by adding the analytical dead load effects to the experimental plots given in Ref. 12.

(iv) The joint shear panel distortion—time diagrams in Fig. 9.13 display permanent deformations which are not exhibited in either experimental or analytical curves given in References 12, 13, and 51. Joint shear panel predicted hysteresis loops shown in Fig. 9.14 and experimental hysteresis loops available in Ref. 12 show inelastic deformations at the joints. The structure that had been tested underwent several test runs prior to this particular run and it would have had residual deformations at the beginning of the test. This would reduce the permanent deformations for

this particular run. It can be observed from Fig. 9.14 (c) that the shear strain oscillates approximately between $2.5\gamma_y$ and $-4\gamma_y$ for the first floor shear panel. If it would have oscillated within a range of $2\gamma_y$, one could attempt to justify the absence of permanent deformations using shake-down principle. Permanent deformations need to be displayed at all the joints where the range of oscillation is greater than $2\gamma_y$, unless the load is applied such that the net permanent deformations are zero. It seems unlikely that with these large inelastic excursions, the net permanent shear deformations would be zero in all the joint shear panels, as reported in the DRAIN 2D analysis. Even Kabe (28) pointed out that DRAIN 2D analysis predicted considerable error in the permanent deformations when a different three-story frame was tested at the University of California, Los Angeles.

(v) The permanent deformations are easily seen only on the joint response curves. It is hard to observe any permanent set in member response curves. This is primarily due to the fact that this example structure is intentionally designed understrength at joints to have large inelastic deformations at the joint shear panels and elastic behavior in the members. Since joint shear panels are the primary structural components that undergo inelastic deformations, the permanent deformations are pronounced in the joint shear panel plots.

(vi) Though DRAIN 2D analysis predicted good results for this example, it did not display any permanent deformations at the joint shear panels. The major factors that would have contributed to this discrepancy are discussed in this paragraph. The DRAIN 2D

assumes linear structural behavior within each time step. It corrects any change in the stiffness of the structure and any unbalance in equilibrium as corrective load, in the subsequent time step. This error is rectified in the FRAME82 analysis by updating the stiffness after each iteration and adding the corrective load at the beginning of next iteration, within a time step. The ignoring of dead load and load history in the DRAIN 2D analysis would also have influenced the joint shear panel response to a considerable extent since shear panels are the primary components that are subjected to inelastic deformations. FRAME82 results reported in this study includes the dead load stresses.

In conclusion, better results could be obtained by using a larger damping in the FRAME82 analysis. It would display residual deformations at the joint shear panels that were not obtained from the DRAIN 2D analysis. The rocking motion of the shaking table can easily be incorporated in the FRAME82 analysis by properly modifying the support conditions of the model.

CHAPTER 10

CONCLUSIONS AND RECOMMENDATIONS

10.1 Conclusions

The main objective of this research was to develop a computer aided analysis of the inelastic static and dynamic behavior of plane frame structures including member and joint shear deformations. A new Discrete Shear Element Model is developed to include member shear deformations along with flexural and axial deformations, and nonlinear geometry. An additional rotational degree of freedom is utilized for each joint to devise a technique to incorporate joint shear deformations. The theory and the developed program FRAME82 are presented in this report. Besides the shear deformations, FRAME82 considers nonlinear geometry, inelastic material response, cyclic loading, inelastic member and joint supports, mass dependent viscous damping, etc. The program formulates the structure stiffness matrix from the stress-strain level of the component materials, and perform member and joint solutions separately using tangent stiffness method.

The program is verified with several simple structures that have theoretical solutions. A pair of structures which were tested at the University of California at Berkeley are analyzed with FRAME82. The analytical results have shown generally good agreement with the experimental responses and the solutions given by other analyses. It is observed that FRAME82 analysis predicts residual deformations of joint shear panels, that were not exhibited in the DRAIN 2D analysis.

10.2 Recommendations

Even though FRAME82 employs efficient solution procedures, it requires more computer time than many other existing programs to analyze a structure. This is due to the fact that the program is highly complex since it formulates the structure stiffness from the stress-strain level. It is, however, very economical to use FRAME82 to analyze a structure, instead of carrying out an experimental investigation. FRAME82 inelastic analysis is recommended for moderate size plane frame structures which have a maximum of 25 joints and 50 members.

With regard to the future of the program, the following improvements and features can be added into the program.

1. The program is currently restricted to rectangular frames with no diagonal bracing when including joint shear deformations in the analysis. The program can be modified so as to include joint shear deformations in the analysis of any plane frame with/without diagonal bracing.

2. The program assumes that the member shear stress does not exceed the yield shear stress and takes only the linear shear deformations into account. A general shear stress-strain curve can be incorporated into the program to include inelastic member shear deformations without much difficulty.

3. Interaction between axial and flexural stresses is considered in the member stiffness formulation. No interaction is considered between shear, and the axial and flexural stresses. Any one of the strain hardening assumptions such as isotropic hardening, kinematic hardening, etc., can be utilized to include the interaction between axial, flexural, and shear stresses.

4. In the case of joints, only the shear deformations are considered in the analysis. More experimental and theoretical investigations are needed to include axial and flexural deformations into the joint shear model.

5. Stiffness dependent viscous damping can be incorporated into the program which presently considers only the mass dependent viscous damping. Stiffness dependent damping plays an important role on the response of the structure at higher modes of vibration.

6. Discrete shear element model can be used only for linear elastic, nonlinear elastic, and masing inelastic stress-strain curves. The new model can be extended to include masing inelasticity with stiffness degradation and special mild steel model type behavior for the member flexural stress-strain curves.

7. Computation of structure stiffness from the stress-strain curves of each member layer facilitates identifying the correct position of plastic hinges, and incorporating the partial plastification of the sections into the analysis. This method requires a lot of bookkeeping operations and more computer time, which makes the FRAME82 analysis very expensive. Instead of performing the analysis at the stress-strain level, the analysis can be made considering the overall behavior of the cross-sections, which is commonly found in literature, at the expense of some accuracy to reduce the computer cost. A comparison can be made between the results obtained by different types of analyses.

8. Lateral and torsional buckling of members and buckling of joint shear panels can be included in the analysis.

9. The program performs inelastic unloading only for structural components which are prescribed to have symmetric stress-strain

curves. The possibility of including a more general stress-strain curve can be studied.

10. Input formats can be extended to include automatic generation of stress-strain curves and cross section data for standard steel sections. This modification would make the program more convenient to the user for design analysis.

11. FRAME82 is written for the analysis of plane frame structures. This can be extended to perform inelastic analysis for three-dimensional frames without losing the important features available in this program. While a three-dimensional static nonlinear elastic program has been written by Mitchell (38), the development of a three-dimensional dynamic, inelastic analysis program with the generality of FRAME82 would require considerable work.

APPENDIX A

DISCRETE SHEAR ELEMENT MATRICES

This appendix contains the matrices involved in the formulation of stiffness matrix for the discrete element shear model discussed in Chapter 3. The required matrices for the stiffness matrix of discrete element flexural model are available in References 22 and 47.

The discrete element deformations δ_a, δ_m, and δ_s, and the angle θ, defined in Eqs. 3.1 through 3.4 are rewritten in Eqs. A.1 through A.4:

$$\delta_a = (2h+\omega_4-\omega_1) \sec \theta - h \cos (\omega_3-\theta) - h \cos (\omega_6-\theta) \tag{A.1}$$

$$\delta_m = \omega_6-\omega_3 \tag{A.2}$$

$$\delta_s = h \sin (\omega_3-\theta) + h \sin (\omega_6-\theta) \tag{A-3}$$

$$\theta = \tan^{-1} \left(\frac{\omega_5-\omega_2}{2h+\omega_4-\omega_1}\right) \tag{A.4}$$

In order to simplify the presentation the following parameters H, ψ_1, and ψ_2 are defined in Eqs. A.5 through A.7.

$$H = 2h+\omega_4-\omega_1 \tag{A.5}$$

$$\psi_1 = \omega_3-\theta \tag{A.6}$$

$$\psi_2 = \omega_6-\theta \tag{A.7}$$

A.1 Initial Stress Stiffness Matrices

In view of Eqs. 3.37 and 3.41, the elements of the initial stress stiffness matrices associated with axial force and shear force, kST_{ij} and kSV_{ij}, can respectively be written as in Eqs. A.8 and A.9:

$$kST_{ij} = T \frac{\partial^2 \delta_a}{\partial \omega_i \partial \omega_j} \qquad (A.8)$$

$$kSV_{ij} = V \frac{\partial^2 \delta_s}{\partial \omega_i \partial \omega_j} \qquad (A.9)$$

The above equations imply that $[k]_{ST}$ and $[k]_{SV}$ are symmetrical square matrices of order 6. Since the computation involves extensive algebra, only the final results are presented herein.

The initial stiffness matrix associated with axial force, $[k]_{ST}$ is given in Eq. A.10:

$$[k]_{ST} = \frac{T}{H^2} \begin{bmatrix} kst_{11} & kst_{12} & kst_{13} & -kst_{11} & -kst_{12} & kst_{16} \\ & kst_{22} & kst_{23} & -kst_{12} & -kst_{22} & kst_{26} \\ & & kst_{33} & -kst_{13} & -kst_{23} & 0 \\ & & & kst_{11} & kst_{12} & -kst_{16} \\ & & & & kst_{22} & -kst_{26} \\ \text{symmetric} & & & & & kst_{66} \end{bmatrix} \qquad (A.10)$$

in which

$$kst_{11} = \frac{H}{2} \sin\theta \sin 2\theta - \delta_s \sin 2\theta \cos^2\theta + \frac{h}{4} \sin^2 2\theta \, (\cos\psi_1 + \cos\psi_2) \qquad (A.10a)$$

$$kst_{12} = -H \sin\theta \cos^2\theta + \delta_s \cos 2\theta \cos^2\theta - \frac{h}{2} \sin 2\theta \cos^2\theta \, (\cos\psi_1 + \cos\psi_2) \qquad (A.10b)$$

$$kst_{13} = -\frac{Hh}{2} \sin 2\theta \cos\psi_1 \qquad (A.10c)$$

$$kst_{16} = -\frac{Hh}{2} \sin 2\theta \cos\psi_2 \qquad (A.10d)$$

$$kst_{22} = H \cos^3\theta + \delta_s \sin 2\theta \cos^2\theta + h \cos^4\theta (\cos\psi_1 + \cos\psi_2) \qquad (A.10e)$$

$$kst_{23} = Hh \cos^2\theta \cos\psi_1 \qquad (A.10f)$$

$$kst_{26} = Hh \cos^2\theta \cos\psi_2 \qquad (A.10g)$$

$$kst_{33} = H^2h \cos\psi_1 \tag{A.10h}$$

$$kst_{66} = H^2h \cos\psi_2 \tag{A.10i}$$

The initial stiffness matrix associated with shear force, $[k]_{sv}$ is presented in Eq. A.11:

$$[k]_{sv} = \frac{V}{H^2} \begin{bmatrix} ksv_{11} & ksv_{12} & ksv_{13} & -ksv_{11} & -ksv_{12} & ksv_{16} \\ & ksv_{22} & ksv_{23} & -ksv_{12} & -ksv_{22} & ksv_{26} \\ & & ksv_{33} & -ksv_{13} & -ksv_{23} & 0 \\ & & & ksv_{11} & ksv_{12} & -ksv_{16} \\ & & & & ksv_{22} & -ksv_{26} \\ \text{symmetric} & & & & & ksv_{66} \end{bmatrix} \tag{A.11}$$

in which

$$ksv_{11} = -h \sin\theta \cos^2\theta (\cos\psi_1+\cos\psi_2) - \frac{\delta_s}{4} \sin^2 2\theta \tag{A.11a}$$

$$ksv_{12} = h \cos 2\theta \cos^2\theta (\cos\psi_1+\cos\psi_2) + \frac{\delta_s}{2} \sin 2\theta \cos^2\theta \tag{A.11b}$$

$$ksv_{13} = \frac{Hh}{2} \sin 2\theta \sin\psi_1 \tag{A.11c}$$

$$ksv_{16} = \frac{Hh}{2} \sin 2\theta \sin\psi_2 \tag{A.11d}$$

$$ksv_{22} = h \sin 2\theta \cos^2\theta (\cos\psi_1+\cos\psi_2) - \delta_s \cos^4\theta \tag{A.11e}$$

$$ksv_{23} = -Hh \cos^2\theta \sin\psi_1 \tag{A.11f}$$

$$ksv_{26} = - Hh \cos^2\theta \sin\psi_2 \tag{A.11g}$$

$$ksv_{33} = - H^2h \sin\psi_1 \tag{A.11h}$$

$$ksv_{66} = -H^2h \sin\psi_2 \tag{A.11i}$$

A.2 Incremental Deformation-Displacement Matrix [B]

An element of the matrix [B] is given in Eq. 3.8 as

$$B_{ij} = \frac{\partial \varepsilon_i}{\partial \omega_j} \tag{A.12}$$

where

$$\{\varepsilon\}^t = [\delta_a, \delta_m, \delta_s] \tag{A.13}$$

and

$$\{\omega\}^t = [\omega_1, \omega_2, \omega_3, \omega_4, \omega_5, \omega_6] \tag{A.14}$$

Thus

$$[B] = \frac{1}{H} \begin{bmatrix} b_{11} & b_{12} & b_{13} & -b_{11} & -b_{12} & b_{16} \\ 0 & 0 & -H & 0 & 0 & H \\ b_{31} & b_{32} & b_{33} & -b_{31} & -b_{32} & b_{36} \end{bmatrix} \tag{A.15}$$

in which

$$b_{11} = -H \cos\theta - \frac{\delta_s}{2} \sin 2\theta \tag{A.15a}$$

$$b_{12} = -H \sin\theta + \delta_s \cos^2\theta \tag{A.15b}$$

$$b_{13} = Hh \sin\psi_1 \tag{A.15c}$$

$$b_{16} = Hh \sin\psi_2 \tag{A.15d}$$

$$b_{31} = -\frac{h}{2} \sin 2\theta \,(\cos\psi_1 + \cos\psi_2) \tag{A.15e}$$

$$b_{32} = h \cos^2\theta \,(\cos\psi_1 + \cos\psi_2) \tag{A.15f}$$

$$b_{33} = Hh \cos\psi_1 \tag{A.15g}$$

$$b_{36} = Hh \cos\psi_2 \tag{A.15h}$$

A.3 Incremental Force-Deformation Matrix [D]

The equations (4.38, 4.41, 4.43, 4.45, 4.46) derived in Chapter 4 are summarized underneath to obtain the incremental force-deformation matrix [D]:

$$[D] = \frac{1}{2h} \begin{bmatrix} \frac{\partial T}{\partial \varepsilon_c} & \frac{\partial T}{\partial \phi} & 0 \\ \frac{\partial M}{\partial \varepsilon_c} & \frac{\partial M}{\partial \phi} & 0 \\ 0 & 0 & \frac{\partial V}{\partial \gamma} \end{bmatrix} \tag{A.16}$$

in which

$$\frac{\partial T}{\partial \varepsilon_c} = \sum_{j=1}^{m} \frac{A_j}{n_j} \sum_{i=1}^{n_j} E_i \tag{A.16a}$$

$$\frac{\partial T}{\partial \phi} = \frac{\partial M}{\partial \varepsilon_c} = - \sum_{j=1}^{m} \frac{A_j}{n_j} \sum_{i=1}^{n_j} y_i E_i \tag{A.16b}$$

$$\frac{\partial M}{\partial \phi} = \sum_{j=1}^{m} \frac{A_j}{n_j} \sum_{i=1}^{n_j} y_i^2 E_i \tag{A.16c}$$

$$\frac{\partial V}{\partial \gamma} = \sum_{j=1}^{m} C_{sj} A_j G_j \tag{A.16d}$$

For the special case of a linear elastic material of modulus of elasticity E and modulus of rigidity G, assuming average cross-sectional area A, shear area A_s, and second moment of area I, the matrix [D] becomes

$$[D] = \frac{1}{2h} \begin{bmatrix} AE & 0 & 0 \\ 0 & EI & 0 \\ 0 & 0 & A_s G \end{bmatrix} \tag{A.17}$$

A.4 Discrete Shear Element Matrices and Other Essential Relationships Excluding Geometric Nonlinearities

The matrices presented in sections A.1 and A.2 include the effects of geometric nonlinearity described in Chapter 3, and the matrices in section A.3 include the material nonlinearity described in Chapter 4. Sometimes, it may be needed to analyze structures considering material nonlinearity and neglecting geometric nonlinearity. Hence, the matrices

given in sections A.1 and A.2, and the deformation-displacement relationships and equlibrium equations given in Chapter 3 are presented beow ignoring geometric nonlinearities.

$$[k]_{ST} = [\mathrm{Null}] \tag{A.18}$$

$$[k]_{SV} = [\mathrm{Null}] \tag{A.19}$$

$$[B] = \begin{bmatrix} -1 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & -1 & 0 & 0 & 1 \\ 0 & 1 & h & 0 & -1 & h \end{bmatrix} \tag{A.20}$$

<u>Deformation-Displacement Relationships</u>

$$\theta = \frac{(\omega_5 - \omega_2)}{2h} \tag{A.21a}$$

$$\delta_a = \omega_4 - \omega_1 \tag{A.21b}$$

$$\delta_m = \omega_6 - \omega_3 \tag{A.21c}$$

$$\delta_s = h(\omega_3 + \omega_6) + (\omega_2 - \omega_5) \tag{A.21d}$$

<u>Equilibrium Equations</u>

$$f_1 = -T \tag{A.22a}$$

$$f_2 = V \tag{A.22b}$$

$$f_3 = -M + Vh \tag{A.22c}$$

$$f_4 = T \tag{A.22d}$$

$$f_5 = -V \tag{A.22e}$$

$$f_6 = M + Vh \tag{A.22f}$$

APPENDIX B

CONSTANT AVERAGE ACCELERATION METHOD

The acceleration $\{\ddot{W}\}$ is assumed to be constant between adjacent time stations. Therefore, the acceleration between stations j and j+1 is given by

$$\{\ddot{W}\} = \frac{1}{2}\{\ddot{W}_j + \ddot{W}_{j+1}\} \tag{B.1}$$

The velocity $\{\dot{W}\}$ at any time within the same interval can be obtained by

$$\{\dot{W}\} = \{\dot{W}\}_j + \int_{t_j}^{t} \{\ddot{W}\}dt$$

i.e. $$\{\dot{W}\} = \{\dot{W}\}_j + \frac{1}{2}(t-t_j)\{\ddot{W}_j + \ddot{W}_{j+1}\} \tag{B.2}$$

Hence, the velocity at station j+1 is

$$\{\dot{W}\}_{j+1} = \{\dot{W}\}_j + \frac{\Delta t}{2}\{\ddot{W}_j + \ddot{W}_{j+1}\} \tag{B.3}$$

where Δt = time increment

The displacement at station j+1 is given by

$$\{W\}_{j+1} = \{W\}_j + \int_{t_j}^{t_{j+1}} \{\dot{W}\}\,dt$$

i.e. $$\{W\}_{j+1} = \{W\}_j + \Delta t\{\dot{W}_j\} + \frac{\Delta t^2}{4}\{\ddot{W}_j + \ddot{W}_{j+1}\} \tag{B.4}$$

Equations B.3 and B.4 are the basis for constant average acceleration

method of numerical integration. The incremental velocity $\{\Delta\dot{W}\}$, and incremental acceleration $\{\Delta\ddot{W}\}$, can be obtained as a function of incremental displacement $\{\Delta W\}$ at time station j, and time increment Δt, from Equations B.3 and B.4 and are given by

$$\{\Delta\dot{W}\}_j = -2\{\dot{W}\}_j + \frac{2}{\Delta t}\{\Delta W\}_j \tag{B.5}$$

$$\{\Delta\ddot{W}\}_j = -2\{\ddot{W}\}_j - \frac{4}{\Delta t}\{\dot{W}\}_j + \frac{4}{\Delta t^2}\{\Delta W\}_j \tag{B.6}$$

APPENDIX C

INPUT GUIDE FOR FRAME82

Units of force, distance, and time must be consistent throughout the input data.
Dimensions of the input variables are given within brackets.
Input data corresponding to the fourth degree of freedom (v) will be disregarded in the analysis if the option (JSYES) to include joint shear deformations is not exercised.

IDENTIFICATION OF RUN
(Two statements per run)

Stat	Col	Format	Entry
1	1-80	10A8	Description to identify the run.
2	1-80	10A8	Continuation of the description.

IDENTIFICATION OF PROBLEM
(One statement per problem)

The program stops if the Problem Number is CEASE.

Stat	Col	Format	Entry
1	1-5	A5	Problem Number.
	6-9	A4	PDNO to exclude geometric nonlinearity.
	11-15	A5	JSYES to incorporate joint shear deformations.
	16-76	A5, 7A8	Description of the Problem.
	77-80	A4	See Note 1

Note 1
Enter MBER for output of member iteration details.
Enter RINT for stiffness matrices output.
Enter SAVE to save member and joint hysteresis on storage devices.

TABLE 1 - PROGRAM CONTROL DATA
(Three statements per problem)

Hold options are specified for Tables 2-7 in the first statement. The program holds data only if data were input in the preceeding problem. Hold option is not applicable for problem types 1 and 9.

Second statement contains output options for Tables 8, 9, and 10.

Number of statements in Tables 2-7 are specified in the third statement.

Stat	Col	Format	Entry
1	1-5	I5	Problem Type (see Note 2)
	6-10	I5	1 to Hold Prior Data for Table 2.
	11-15	I5	1 to Hold Prior Data for Table 3A.
	16-20	I5	1 to Hold Prior Data for Table 3B.
	21-25	I5	1 to Hold Prior Data for Table 3C.
	26-30	I5	1 to Hold Prior Data for Table 4A.
	31-35	I5	1 to Hold Prior Data for Table 4B.
	36-40	I5	1 to Hold Prior Data for Table 4C.
	41-45	I5	1 to Hold Prior Data for Table 4D.
	46-50	I5	1 to Hold Prior Data for Table 4E.
	51-55	I5	1 to Hold Prior Data for Table 5A.
	56-60	I5	1 to Hold Prior Data for Table 5B.
	61-65	I5	1 to Hold Prior Data for Table 5C.
	66-70	I5	1 to Hold Prior Data for Table 5D.
	71-75	I5	1 to Hold Prior Data for Table 6. 2 to Hold Prior Data for Table 6 and then to Modify by a certain % to be specified in Table 6.
	76-80	I5	1 to Hold Prior Data for Table 7.

Note 2

Available problem types are listed below:

1 - A new problem (always static) - Results not held from preceding problem.
2 - Static problem - Results held from preceding satic problem.
3 - Dynamic problem - Results held from preceding static problem.
4 - Dynamic problem - Results held from preceding dynamic problem.
9 - Read for structure data only - Does not affect the results of the preceding problem available on disk from prior run.

Stat	Col	Format	Entry
2	1-5	I5	1 to suppress output Table 8 in Static analysis. or Increments of time steps after which Table 8 is to be printed during Dynamic analysis.
	6-10	I5	1 to suppress output Table 9 in Static analysis. or Increments of time steps after which Table 9 is to be printed during Dynamic analysis.
	11-15	I5	1 to suppress output Table 10 in Static analysis. or Increments of time steps after which Table 10 is to be printed during Dynamic analysis.

Stat	Col	Format	Entry
3	6-10	I5	Number of Statements in Table 2.
	11-15	I5	Number of Statements in Table 3A.
	16-20	I5	Number of Statements in Table 3B.
	21-25	I5	Number of Statements in Table 3C.

26-30	I5	Number of Statements in Table 4A.
31-35	I5	Number of Statements in Table 4B.
36-40	I5	Number of Statements in Table 4C.
41-45	I5	Number of Statements in Table 4D.
46-50	I5	Number of Statements in Table 4E.
51-55	I5	Number of Statements in Table 5A.
56-60	I5	Number of Statements in Table 5B.
61-65	I5	Number of Statements in Table 5C.
66-70	I5	Number of Statements in Table 5D.
71-75	I5	Number of Statements in Table 6.
76-80	I5	Number of Statements in Table 7.

TABLE 2 - FRAME GEOMETRY DATA
(Number of statements as per Table 1)

Stat	Col	Format	Entry
1	11-15	I5	Number of Joints.
	21-25	I5	Reference Joint.
	31-40	E10.3	X-Coordinate of the reference joint [d].
	41-50	E10.3	Y-Coordinate of the reference joint [d].
	61-70	E10.3	Joint Location Tolerance [d].

2nd and succeeding statements prescribe the x and y offsets of the TO joints with respect to the FROM joint.

Stat	Col	Format	Entry
2/2+	11-15	I5	From Joint.
	21-30	E10.3	X-Offset [d].
	31-40	E10.3	Y-Offset [d].
	46-80	7I5	TO Joints (see Note 3).

Note 3

Several joints can be specified in one statement if offsets between any two adjacent TO joints are equal to the offset between the FROM joint and the first TO joint

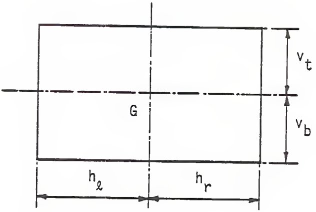
TABLE 3A - JOINT DATA
(Number of statements as per Table 1)

Stat	Col	Format	Entry
1	1-5	I5	Number of Joint Stiffness Types.

2nd and succeeding statements specify the joint stiffness type for each joint.

Stat	Col	Format	Entry
2/2+	1-5	I5	Joint Stiffness Type.
	11-80	14I5	Joint Numbers.

3rd and successive statements give the dimensions and shear stress-strain curve for each joint stiffness type.



Stat	Col	Format	Entry
3/3+	1-5	I5	Joint Stiffness Type.
	11-15	E10.3	h_ℓ [d].
	21-30	E10.3	h_r [d].
	31-40	E10.3	v_b [d].
	41-50	E10.3	v_t [d].
	51-60	E10.3	Thickness of the panel [d].
	61-70	E10.3	Modulus of Rigidity* [f/d^2].
	71-75	I5	Shear Stress-Strain Curve Number*.

* Either modulus of rigidity or curve number can be specified.

TABLE 3B - JOINT SHEAR STRESS-STRAIN CURVES
(Number of statements as per Table 1: Two per curve)

The program is currently restricted to Masing inelastic behavior. Hence, leave the columns corresponding to material and stiffness degradation factors blank.

Stat	Col	Format	Entry
1	2-5	A4	Material (Enter MILD if the special model for mild steel is to be used. Otherwise, leave it blank).
	6-10	I5	Curve Number.
	11-15	I5	Number of Points.
	16-20	I5	Symmetry Option (see Note 4).
	21-30	E10.3	Stiffness Degradation α Factor.
	31-40	E10.3	Stiffness Degradation β Factor.
	41-80	8I5	Shear Stress - Values.

Stat	Col	Format	Entry
2	1-10	E10.3	Shear Stress Multiplier [f/d^2].
	11-20	E10.3	Shear Strain Multiplier [d/d].
	41-80	8I5	Shear - Strain Values.

Note 4

If equal to 1 a symmetrical branch is provided internally. The first stress and strain values must be zero if the symmetry option is used. The curve must be symmetric to perform inelastic analysis.

TABLE 3C - MEMBER LOCATION DATA
(Number of statements as per Table 1)

Stat	Col	Format	Entry
1	11-15	I5	Number of Member Stiffness Types.
	21-25	I5	Number of Member Load Types.

2nd and succeeding statements prescribe stiffness and load types for every member.

Stat	Col	Format	Entry
2/2+	6-10	I5	FROM Joint.
	16-20	I5	Stiffness Type.
	21-25	I5	Load Type.
	31-80	10I5	TO Joints (see Note 5).

Note 5
Members with same stiffness and load types as of the member connecting the FROM and first TO joints, can be specified if the FROM joint of each new member is the TO joint of the previous one.

TABLE 4A - INCREMENTAL JOINT LOADS AND SUPPORT LINEAR RESTRAINTS IN STRUCTURE x, y, and z AXES
(Number of joints as per Table 1: Two statements per joint)

Stat	Col	Format	Entry
1	1-5	I5	Joint.
	11-20	E10.3	Load Parallel to x-Axis [f].
	21-30	E10.3	Load Parallel to y-Axis [f].
	31-40	E10.3	M_z Moment [fd].
	41-50	E10.3	M_y Moment [fd].

Stat	Col	Format	Entry
2	11-20	E10.3	Restraint Parallel to x-Axis [f/d].
	21-30	E10.3	Restraint Parallel to y-Axis [f/d].
	31-40	E10.3	R_z Restraint [fd].
	41-50	E10.3	R_y Restraint [fd].
	71-80	E10.3	Mass [f/g] (see Note 6).

Note 6
A negative input mass will cause mass to be omitted in equation of motion for structure y displacement and a positive mass to be used in equation of motion in structure x direction. A positive input mass makes the program to use mass in both x and y equations.

TABLE 4B - NONLINEAR JOINT SUPPORTS
(Number of statements as per Table 1)

Stat	Col	Format	Entry
1	1-5	I5	Joint.
	11-20	E10.3	Q-Multiplier [f or fd].
	21-30	E10.3	W-Mulitplier [f or fd].

41-45	I5	Curve Number of Force Restraint // to x-Axis.
46-50	I5	Curve Number of Force Restraint // to y-Axis.
51-55	I5	Curve Number of Moment Restraint about z Direction.
56-60	I5	Curve Number of Moment Restraint about v Direction.
61-65	I5	Curve Number of Force Restraint // to x'-Axis.
66-70	I5	Curve Number of Force Restraint //to y'-Axis.
76-80	I5	Stiffness Type (see Note 7).

Note 7

If curves are specified along member directions, stiffness type of the member is required.

TABLE 4C - NONLINEAR SUPPORT CURVES

(Number of statements as per Table 1: Two per curve)

Stat	Col	Format	Entry
1	6-10	I5	Curve Number.
	11-15	I5	Number of Points.
	16-20	I5	Symmetry Option (see Note 8).
	26-80	11I5	Q-Values.

Stat	Col	Format	Entry
2	26-80	11I5	W-Values.

Note 8

If equal to 1, a symmetrical branch is provided internally. The first Q and W values must be zero if symmetry option is equal to 1. In this case, Q-W will be inelastic of the Masing type.

TABLE 4D - DYNAMIC JOINT FORCES

(Number of statements as per Table 1)

Stat	Col	Format	Entry
1	6-10	I5	Joint Number.
	11-20	E10.3	F_x-Axis Multiplier [f].
	21-30	E10.3	F_y-Axis Multiplier [f].
	31-40	E10.3	M_z-Axis Multiplier [fd].
	41-50	E10.3	M_y-Axis Multiplier [fd].
	51-60	E10.3	Time Axis Multiplier [t].
	61-65	I5	Curve Number // to x Axis.
	66-70	I5	Curve Number // to y Axis.
	71-75	I5	Curve Number // to z Direction.
	76-80	I5	Curve Number // to v Direction.

TABLE 4E - DYNAMIC JOINT FORCE CURVES

(Number of statements as per Table 1: nominally 2 statements per curve)

Stat	Col	Format	Entry
1	6-10	I5	Curve Number.
	11-15	I5	Number of Points.
	26-80	11I5	Force Values.
1+	1-80	16I5	Continue the remaining Force Values on the succeeding statements.

Stat	Col	Format	Entry
2	26-80	11I5	Time Values.
2+	1-80	16I5	Continue the remaining Time Values on succeeding statements.

TABLE 5A - MEMBER STIFFNESS TYPES

(Number of statements as per Table 1: Number of sets of statements is equal to the number of stiffness types defined in this problem)

Stat	Col	Format	Entry
1	1-5	I5	Stiffness Type.
	6-10	I5	Number of Elements (see Note 9).
	11-20	E10.3	Modulus of Elasticity [f/d^2] (Blank if Nonlinear Option=1).
	21-25	A5	Element Type. SHEAR if member shear deformations are to be included. FLEX to neglect member shear deformation effects.
	31-40	E10.3	Prismatic Moment of Inertia [d^4] (Blank if specified below).
	41-50	E10.3	Prismatic Area [d^2] (Blank if specified below).
	51-55	I5	Nonlinear Option. Blank to exclude material nonlinearity effects. 1 to include material nonlinearity effects.
	56-60	I5	Number of Statements that Follow.
	61-65	I5	Axis Option. 1, if restraints are in the direction of member axes. 2, if restraints are in the direction of structure axes. In both cases, restraints are per unit of length along the member x'-axis, and distances are along the member x'-axis.
	66-70	I5	Output Option. If Blank, complete beam-column output is given. If 1, only member end forces are given.
	71-75	I5	FROM Joint Option (see Note 10).
	76-80	I5	TO Joint Option (see Note 11).

Note 9

Number of elements must be between 4 and 20. If Blank, 20 elements are used. If even number of elements are used, displacements and equilibrium errors are printed at the center station for monitor member. If odd number of elements are used, they are printed at the first station from the center towards the FROM joint.

Note 10

If 1, the member is assumed pinned to joint at FROM end. If Blank, the member is assumed rigidly connected to joint at FROM end. If -ij, the member is assumed to be rigidly connected to the joint at FROM end and to have i rigid discrete elements followed by j discrete elements that remain linear regardless of stress level.

Note 11

If 1, the member is assumed pinned to joint at TO end. If Blank, the member is assumed rigidly connected to joint at TO end. If -ij, the member is assumed to be rigidly connected to the joint at TO end and to have i rigid discrete elements followed by j discrete elements that remain linear regardless of stress level.

2nd statement is required only for Prismatic Members with Element Type = SHEAR and Nonlinear Option Blank.

Stat	Col	Format	Entry
2	1-10	E10.3	Modulus of Rigidity [f/d^2].
	11-20	E10.3	Effective Shear Area [d^2].

3rd and succeeding statements of the set if Nonlinear Option is Blank and Element Type = FLEX. An example presented at the end of this appendix illustrates the input of this particular statement.

Stat	Col	Format	Entry
3/3+	11-20	E10.3	From (Distance) [d].
	21-30	E10.3	To (Distance) [d].
	31-40	E10.3	Moment of Inertia (I) [d^4].
	41-50	E10.3	Flexural Area (A) [d^2].
	51-60	E10.3	Restraint // to x' or x Axis ($S_{x'}$) [f/d^2].
	61-70	E10.3	Restraint // to y' or y Axis ($S_{y'}$) [f/d^2].
	71-80	E10.3	Rotational Restraint about z'-Axis ($S_{z'}$) [f].

3rd and succeeding statements of the set if Nonlinear Option = 1.

Stat	Col	Format	Entry
3/3+	11-15	I5	Cross Section # at FROM Joint.
	15-20	I5	q-w Curve # at FROM Joint // to x' or x Axis.
	21-25	I5	q-w Curve # at FROM Joint // to y' or y Axis.
	26-30	I5	q-w Curve # at FROM Joint about z' Axis.
	36-40	I5	Cross Section # at TO Joint.
	41-45	I5	q-w Curve # at TO Joint // to x' or x Axis.
	46-50	I5	q-w Curve # at TO Joint // to y' or y Axis.

51-55	I5	q-w Curve # at TO Joint about z' Axis.
61-70	E10.3	q-Multiplier [f/d or f].
71-80	E10.3	w-Multiplier [d or d/d].

TABLE 5B - CROSS-SECTION PROPERTIES

(Number of statements as per Table 1: Number of sets of statements is equal to the number of cross-sections defined in this problem.)

1st statement of the set.

Stat	Col	Format	Entry
1	6-10	I5	Cross-Section Number.
	11-15	I5	Number of Statements that Follow.

2nd and succeeding statements of the set.

Stat	Col	Format	Entry
2/2+	6-10	I5	Number of Equal Layers (see Note 12).
	11-20	E10.3	Width or Outside Diameter [d].
	21-30	E10.3	Depth or Thickness [d].
	31-40	E10.3	Centroidal Distance [d].
	41-45	I5	Area Option. If Blank, input is properties of rectangle. If equal to 1, input is properties of thin wall tube.
	46-50	I5	Curve Number.
	51-60	E10.3	Stress-Multiplier [f/d^2].
	61-70	E10.3	Strain-Multiplier [d/d].
	71-80	E10.3	Shear Area Coefficient.

Note 12

If Blank, σ-ε will be nonlinear but elastic. If not, σ-ε must be symmetric for inelastic treatment, and the sum total of all the layers in a cross section must be $\leqslant 10$.

TABLE 5C - MEMBER STRESS-STRAIN CURVES

(Number of statements as per Table 1: Two per curve if flexural model is employed and Three per curve if shear model is employed.)

Stat	Col	Format	Entry
1	2-5	A4	Material (Enter MILD if the special model for mild steel is to be used. Otherwise, leave it Blank).
	6-10	I5	Curve Number.
	11-15	I5	Number of Points (see Note 13).
	16-20	I5	Symmetry Option (see Note 14).
	21-30	E10.3	Stiffness Degradation α Factor.
	31-40	E10.3	Stiffness Degradation β Factor.
	41-80	8I5	Flexural Stress - Values.

Stat	Col	Format	Entry
2	41-80	8I5	Flexural Strain - Values.

Note 13

If σ-ε is to follow inelastic path, number of points including origin must be ≤ 4.

Note 14

If equal to 1, a symmetrical branch is provided internally. The first stress and strain values must be zero if the symmetry option is used. The curve must be symmetric to perform inelastic analysis.

3rd statement is required for the set only if discrete element shear model is employed for this particular cross-section.

Stat	Col	Format	Entry
3	1-10	E10.3	Elastic Shear Modulus [f/d^2].

TABLE 5D - NONLINEAR MEMBER SUPPORT CURVES

(Number of statements as per Table 1: Two per curve)

Stat	Col	Format	Entry
1	6-10	I5	Curve Number.
	11-15	I5	Number of Points.
	16-20	I5	Symmetry Option (see Note 15).
	26-80	11I5	q-Values.

Stat	Col	Format	Entry
2	26-80	11I5	w-Values.

Note 15

If equal to 1, a symmetrical branch is provided internally. The first q and w values must be zero if the symmetry option is used. Then, q-w will be inelastic of the Masing type.

TABLE 6 - MEMBER LOAD DATA

(Number of statements as per Table 1: Number of sets of statements equal to the number of load types defined in this problem)

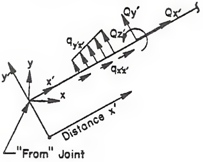
Member loads may be input by any one of the four axis options outlined below:

Q_a is the concentrated load in the direction of the a-axis.

q_{ab} is the distributed load in the direction of the a-axis and has its intensity per unit of length along the b-axis.

Concentrated loads may not be input at distance of 0.0.

AXIS OPTION 1



1st statement of the set.

Stat	Col	Format	Entry
1	6-10	I5	Load Type.
	11-20	E10.3	% Increase in Load. Blank Unless Hold Option = 2.
	21-25	A5	DITTO (see Note 16).
	31-40	E10.3	Uniform Load // to x' Axis ($q_{x'x'}$) [f/d]. Blank, if second statement is used.
	41-50	E10.3	Uniform Load // to y' Axis ($q_{y'y'}$) [f/d]. Blank, if second statement is used.
	56-60	I5	Number of Statements that Follow.
	61-65	I5	1 (Axis Option).
	80	A1	* (see Note 17).

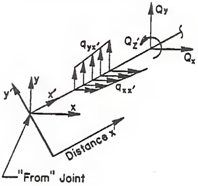
Note 16
An entry of DITTO will cause all the load types higher than the current load type being defined to have the same % increase without providing additional data statements for them.

Note 17
An entry of * overrides any % of load increase or reduction specified in Table 6 or Table 7 and maintains constant member load.

2nd and succeeding statements of the set.

Stat	Col	Format	Entry
2/2+	11-20	E10.3	From Distance x' (along member) [d].
	21-30	E10.3	To Distance x' (along member) [d].
	31-40	E10.3	Load // to x'-Axis. $Q_{x'}$ or $q_{x'x'}$ [f or f/d].
	41-50	E10.3	Load // to y'-Axis. $Q_{y'}$ or $q_{y'x'}$ (f or f/d).
	51-60	E10.3	Moment about z'-Axis. $Q_{z'}$ or $q_{z'x'}$ [fd or f].
	80	A1	* (see Note 17).

AXIS OPTION 2



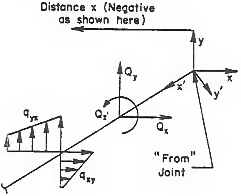
1st statement of the set.

Stat	Col	Format	Entry
1	6-10	I5	Load Type.
	11-20	E10.3	% Increase in Load. Blank Unless Hold Option = 2.
	21-25	A5	DITTO (see Note 16).
	31-40	E10.3	Uniform Load // to x-Axis ($q_{xx'}$) [f/d]. Blank, if second statement is used.
	41-50	E10.3	Uniform Load // to y-Axis ($q_{yy'}$) [f/d]. Blank, if second statement is used.
	56-60	I5	Number of Statements that Follow.
	61-65	I5	2 (Axis Option).
	80	A1	* (see Note 17).

2nd and succeeding statements of the set.

Stat	Col	Format	Entry
2/2+	11-20	E10.3	From Distance x' (along member) [d].
	21-30	E10.3	To Distance s' (along member) [d].
	31-40	E10.3	Load // to x'Axis. Q_x or $q_{xx'}$ [f or f/d].
	41-50	E10.3	Load // to y'-Axis. Q_y or $q_{yx'}$ [f or f/d].
	51-60	E10.3	Moment about z'-Axis. $Q_{z'}$ or $q_{z'x'}$ [fd or f].
	80	A1	* (see Note 17).

AXIS OPTION 3



1st statement of the set.

Stat	Col	Format	Entry
1	6-10	I5	Load Type.
	11-20	E10.3	% Increase in Load. Blank Unless Hold Option = 2.
	21-25	A5	DITTO (see Note 16).
	31-40	E10.3	Uniform Load // to x-Axis (q_{xy}) [f/d]. Blank, if second statement is used.
	41-50	E10.3	Uniform Load // to y-Axis (q_{yx}) [f/d]. Blank, if second statement is used.
	56-60	I5	Number of Statements that Follow.
	61-65	I5	3 (Axis Option).
	80	A1	* (see Note 17).

2nd and succeeding statements of the set.

Stat	Col	Format	Entry
2/2+	11-20	E10.3	From Distance x (along structure axis) [d].
	21-30	E10.3	To Distance x (along structure axis) [d].
	31-40	E10.3	Load // to x-Axis. Q_x or q_{xy} [f or f/d].
	41-50	E10.3	Load // to y-Axis. Q_x or q_{yx} [f or f/d].
	51-60	E10.3	Moment about z'-Axis. $Q_{z'}$ or $q_{z'x'}$ [fd or f].
	80	A1	* (see Note 17).

AXIS OPTION 4

It is identical to Axis Option 3 except distances are in structure y-axis and 4 is input in column 65 of the first statement.

The member x'-axis goes from the FROM joint to the TO joint. The FROM and TO joints are determined by input of Table 3. An example illustrating various axis options is given at the end of this appendix (22).

TABLE 7 - ITERATION CONTROL

(Two statements unless held from previous problem)

1st statement contains frame solution parameters.

Stat	Col	Format	Entry
1	1-5	I5	# of Load Reductions.
	6-10	I5	# of Time Step Halvings.
	11-15	I5	Maximum Number of Iterations.
	16-20	I5	# of Time Steps.
	21-30	E10.3	Force Error [f].
	31-40	E10.3	Moment Error [fd].
	41-50	E10.3	Size of Time Step [t].
	51-55	F5.2	% Reduction of Joint Load.
	56-60	I5	Total Number of Monitor Joints (≤ 20).
	61-80	4I5	Monitor Joint Numbers.

+1	1-80	16I5	Continue the remaining Monitor Joint Numbers on the succeeding statements.

2nd statement contains member solution parameters and damping coefficient.

Stat	Col	Format	Entry
2	1-10	E10.3	Mass Dependent Damping Constant (α) [1/t].
	11-15	I5	Monitor Joint option (see Note 18).
	16-20	I5	Maximum Number of Iterations.
	21-30	E10.3	Force Error [f].
	31-40	E10.3	Moment Error [fd].
	51-55	F5.2	% Reduction of Member Load.
	56-60	I5	Total Number of Monitor Members (≤ 20).
	61-80	4I5	Monitor Member Numbers.
2+	1-80	16I5	Continue the remaining Monitor Members on the succeeding statements.

Note 18

0 for output of actual displacements of monitor joints in time varying plots.

1 for output of monitor joint displacements with respect to first monitor joint in time varying plots.

2 for output of monitor joint displacements with respect to the previously input monitor joints in time varying plots (i.e. i+1 with respect to i).

COMMENTS ON INPUT GUIDE

General

The data statements must be stacked in proper order for the program to run.

The last statement of the data must contain CEASE in the first five columns to stop execution.

A consistent system of units of force [f], distance [d], and time [t] must be used for all input data - e.g., pounds, inches, and seconds.

Input data correspond to fourth degree of freedom (v) will be disregarded in the analysis if JSYES (Joint Shear YES) option is not specified.

MBER (meMBER) and RINT (pRINT) options will assist you to detect any convergence problems. Remember that these options will produce huge output.

SAVE option saves member and joint hysteresis on storage devices.

Majority of the five-space words are integers.

All ten-space words are floating-point decimal numbers.

All numbers must be right justified.

The Problem Number may contain alphanumeric characters.

Table 1 - Program Control Data

Data are accumulated in Tables 2 through 7 until the corresponding Hold Options are left blank in Table 1.

The maximum number of statements that can be accumulated in Table 5A is 50 plus the number of Stiffness Types.

The maximum number of statements that can be accumulated in Table 6A is 75 plus the number of Load Types.

Type 1 problems start the iterative solution with zero displacements.

Type 2, 3, and 4 problems use the displacements of the previous problem in their first iteration.

Type 9 problem reads structure data only.

Output Options for dynamic solutions require input of the time step increment between output. A zero or blank gives output only the final time step. A one gives output for every time step and generates a lot of output.

Table 2 - Frame Geometry Data

The first statement gives the total number of joints in the frame, which must not exceed 25.

The reference joint, its coordinates, and the joint location tolerance are given only if the Hold Option for Table 2 is not exercised.

Joints are numbered from 1 to the total number of joints. A joint number may not be deleted in a series unless the Hold Option is not exercised. However, the joint may be structurally deleted by removing all members intersecitng at the joint.

The reference joint may be any joint and it may have any coordinates, except that it and other joint coordinates must be less than 1.0E+20.

The maximum difference in joint numbers, for joints that are connected by members is 5.

The second and succeeding statements in Table 2 specify the location of all additional joints in the frame at least once. If Hold Option is used, only the new joints must be specified.

All offsets must be FROM a previously located joint TO another joint. The TO joint may be a previously defined joint. This allows the user to check the locations of the joints. If the error in the location of the joint is within the joint location tolerance, then the solution continues; otherwise, the solution terminates with an appropriate diagnostic.

The joint location tolerance should allow for normal round-off error. If offsets are input to the nearest 0.1 inch, then a joint location tolerance of 0.3 inch will be usually sufficient for a moderate-sized frame.

The repetition of the TO joint allows the user to locate up to seven joints with one statement, if the offsets between the adjacent new TO joints are the same as between the FROM joint and the first TO joint.

It is not necessary for offsets to be given at locations where members are. However, the location of all joints must be specified at least once.

Table 3A - Joint Data

The joint data is required to incorporate the joint shear deformation effects into the analysis. Only the rectangular joint panels can be prescribed at present.

The first statement gives the total number of Joint Stiffness Types in the frame, which must not exceed 25.

In order for the joints to have same stiffness type, they must have the same dimensions and stress-strain properties.

Joints with the same stiffness type can be specified in a single statement. However, a maximum of 14 joint numbers can be specified in any desired order in a single statement.

Joint Stiffness Type of zero (0) may be input to include joints with negligible stiffness (dimensions).

The properties of the Joint Stiffness Types can be input in any order.

Either modulus of rigidity or joint shear stress-strain curve shall be specified.

A maximum of eight different joint shear stress-strain curves can be specified.

Table 3B - Joint Shear Stress-Strain Curve

The joint shear stress-strain curves need not be input in the order of the curve numbers.

The τ-γ curves must be input such that the γ values are in the ascending algebraic order.

Usually shear stress and shear strain values will have the same sign.

A maximum of eight points can be input for each curve.

Anti-symmetrical curves may be input by specifying only the positive displacement branch including the origin (0,0).

Table 3C - Member Location Data

The first statement gives the total number of member stiffness types and the total number of member load types.

Member stiffness and load types (other than zero) are numbered from one to their total number. The total number of member stiffness and load types must not exceed 25 individually.

The total number of members in the frame must not exceed 50.

Type zero stiffness is used to delete a previously defined stiffness. Type zero load is used to indicate no load on the member. The restrictions on length, orientation etc. outlined below, do not apply to members with zero stiffness type and zero load type.

In order for two members to have the same stiffness type, they must have the same length, the same angular orientation in the frame, and the same stiffness properties with respect to their FROM and TO joints.

In order for two members to have the same load type, they must have the same length, the same angular orientation in the frame, and the same stiffness properties with respect to their FROM and TO joints.

The member coordinate axes are defined by the FROM and TO joints specified. The member x'-axis starts at the FROM joint and goes to the TO joint. The member y'-axis and z'-axis are located from the member x'-axis by the right hand rule.

All members in the frame must be assigned a stiffness type and a load type. This assignment is not accumulative for a member in the frame; i.e., the last values of stiffness and load types specified replace the previous values. Thus, stiffness and load types of a member must be specified on the same statement.

Up to ten members with the same stiffness and load types may be located with a single statement if the FROM joint of each new member is the TO joint of the previous one.

Table 4A - Incremental Joint Loads and Support Linear Restraints

All joint loads and linear supports (restraints) are specified with respect to the structure axes.

Joint loads and restraints are accumulated in Table 4A.

M_v moment and R_v restraint will be included in the analysis only if JSYES option is exercised.

Structure supports may be input as linear elastic joint restraints (springs). Complete fixity of a joint may be achieved by inputting a very large value for the spring stiffness. No round-off errors are encountered when extremely large values are specified unless large values are input and then subtracted away.

Complete freedom of joint movements is obtained by not specifying any restraints at a joint.

A displacement may be enforced by specifying a very large restraint and a corresponding force equal to the desired displacement times the large restraint.

Table 4B - Nonlinear Joint Supports

The latest curve numbers, including zero (which deletes any old curve number), replace the old curve numbers at a joint. Curves may have any number from 1 to 20.

A joint may have both linear supports (Table 4A) and nonlinear supports (Table 4B)

Curve number corresponding to moment restraint in the v-direction is considered only if JSYES option is specified.

Curves may be specified in both structure and member directions. If curves are specified in member directions, then the stiffness type of the member which the curves are referenced to must be given.

The Q and W multipliers input in Table 4B times the Q-W curves input in Table 4C yield the final Q-W values at a joint.

The ratio of the final Q-values to the final W-values should not be many orders of magnitude larger than the stiffness data for the members of the frame, if the supports are specified in member directions.

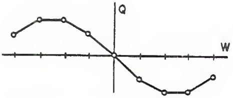
Table 4C - Nonlinear Support Curves

The Q-W curves do not have to be input in the ascending order of the curve numbers.

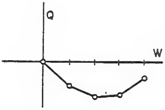
The Q-W curves must be input such that the final W values will be in ascending algebraic order.

Normal Q-W curves will have opposite signs for displacements and forces.

Anti-symmetrical curves may be input by specifying only the positive displacement branch including the origin.



Anti-Symmetrical Curve



Input Curve

Table 4D - Dynamic Joint Forces

Dynamic joint forces need not be input in the ascending order of the joint numbers.

Joint load curve number shall not exceed 20.

Curve number corresponding to M_y moment is ignored in the analysis if JSYES option is not specified.

TAble 4E - Dynamic Joint Force Curves

The latest force-time values input to the dynamic joint force curve replace the previously assigned values.

Curves can be input in any desired order.

A maximum of 300 points can be input for a curve.

Table 5A - Member Stiffness Types

Stiffness type must be input in ascending order. If Table 5A is held from the previous problem, then the first new stiffness type in Table 5A (if any) must be equal to the number of stiffness types in the last problem plus one.

Discrete element flexural and shear models can be specified for prismatic members and members with material nonlinearity. But only flexural model can be specified for members with linearly varying stiffness properties.

Prismatic members with FLEX (flexural) element type and a single modulus of elasticity may be input with one statement, if no member restraint is present. Other members with FLEX element type require two or more statements.

Prismatic members with SHEAR element type and a single modulus of elasticity may be input with two statements, if the member has no restraints. Other members with SHEAR element type require three or more statements.

If more than one statement is used to describe a member stiffness type with FLEX element type, the prismatic stiffness properties must be left blank.

If more than two statements are used to describe a member stiffness type with SHEAR element type, the prismatic stiffness properties must be left blank.

If the nonlinear option is left blank, then the third and succeeding statements describe the variation in the linear stiffness properties of the members. This type of input is illustrated later in this appendix.

If any of the member stiffness properties are nonlinear, the nonlinear option is set equal to one and the third statement gives the cross section numbers, and q-w curve numbers, and q and w multipliers, at the member FROM and TO joints. Then the cross section properties, stress-strain curves, and q-w curves are defined in Tables 5B, 5C, and 5D.

The final q-w values used are the product of the q and w multipliers and the q-w curves input in Table 5D.

The latest multipliers, cross section numbers, and curve numbers replace the old data, if any, at a joint.

Cross sections and q-w curves may have any number from 1 to 20.

Effective shear area is equal to the shear carrying area divided by shear area factor. Note that shear area factor is very similar to the inverse of shear area coefficient used in Table 5B.

Table 5B - Cross Section Properties

Cross-sections do not have to be input in the order of their numbers.

Cross sections are defined as a series of up to 10 peices. Each peice may be either a rectangle or a thin wall tube and have a unique flexural stress-strain curve number up to 8. The final stress-strain values are the product of the stress and strain multipliers, and the stress-strain curves input in Table 5C. (Each piece may be subdivided into specified number of layers for inelastic treatment. The total number of sublayers for the whole cross section must be $\leq$ 10.)

The centroidal distance input for the tube and the rectangle is the distance from the member x'-axis to the centroid of the pipe or rectangle. This distance is positive if it is along the direction of the member y'-axis. Linear interpolation along the length of the member between corresponding pieces is provided in the program. Thus, the cross section input at the two end joints should have the same number of pieces and pieces should be input in the same order. Interpolation between a rectangular piece and a tubular piece is not allowed.

All data input for a cross section number replaces the previous data, if any, for that cross-section number.

Shear area coefficient times the area of the piece is the contribution of the piece to the shear area of the cross-section. The summation of such areas gives the effective shear area for the cross-section.

Table 5C - Member Stress-Strain Curves

Member flexural stress-strain curves are input similar to the Q-W curves of Table 4C. Normally, stress and strain values will have the same sign.

Corresponding pieces in the cross-sections at the two end joints must have the same number of points on their flexural stress-strain curves. This allows linear interpolation along the length of the member. If inelastic algorithm is specified, the corresponding pieces must have exactly the same σ-ε curve at the two ends of the member.

Elastic shear modulus is specified only if discrete element SHEAR model is used for the particular member.

Table 5D - Nonlinear Member Support Curves

Member support curves (q-w) are input similar to the Q-W curves of Table 4C. However, the final q values will have the unit of force per unit distance.

The q-w curves at both joints of a member must have the same number of points. This allows linear interpolation along the length of the member.

Table 6 - Member Load Data

Load types must be input in ascending order. If Table 6 is held from the previous problem then the first new load type in Table 6 (if any) must be equal to the number of load types in the last problem plus one.

If the Hold Option for Table 6 is set equal to two (2) in Table 1, then Table 6 must have one statement for each old type, which has the load type and the percent (25 percent = 25.0) increase in absolute value of all loads described in that load type, plus whatever statements are needed to define any new load types.

Load types with only uniform loads over the full member length may be input with only one statement. Other loadings require two or more statements.

If more than one statement is used to describe a member load type, the uniform loads on the first statement must be left blank.

Variable, concentrated, and partial uniform loadings must be input in sections but need not be input consecutively, and sections may overlap. This format is illustrated later in this appendix.

All sections, except concentrated loads, must have their TO distance larger in absolute value than their FROM distance by more than the length of one discrete element.

Concentrated loads may not be specified at a distance of 0.0.

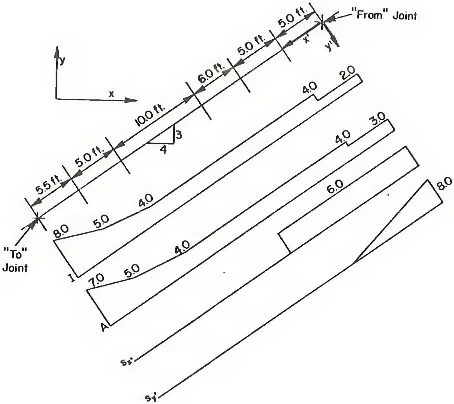
Table 7 - Iteration Control

The maximum number of iterations for the frame and member solutions should be specified to save computer time. Normally, convergence will be reached within five or ten iterations. An upper limit of 20 is set in the program.

The allowable equilibrium errors may be set by the following procedure until the user develops his own special requirements. Select as a force and a moment that would have a negligible effect on the frame if applied at any point in the frame. (For example, the designer may know the value of his loads to the nearest 0.1 kips. Then a reasonable joint force error would be 0.01 kips, and a reasonable moment error would be 0.01 kips times the length of a typical member.) The errors permitted in the member solution should be 0.1 times the corresponding joint errors to allow for round-off.

Monitor joints and members options may help to study the iteration process, particularly if the solution fails to converge. The numbers of the monitor members are the ones assigned by the program in the order in which the members are input in Table 3C. In a dynamic problem, hysteresis information will be output for monitor members only, and the time history of displacements and shear moments will be printed and plotted for monitor joints only.

A maximum of 20 monitor joints and 20 monitor members can be specified.



Variable Linear Member Stiffness Properties

	From	To	I	A	s_x'	s_y'	s_z'
*	0.0		2.0	3.0	6.0	8.0	
		5.0	2.0	3.0	6.0	4.0	
*	5.0		4.0	4.0	6.0	4.0	
		10.0	4.0	4.0	6.0	0.0	
•	10.0	16.0	4.0	4.0	6.0		
•	16.0	26.0	4.0	4.0			
*	26.0		4.0	4.0			
		31.0	5.0	5.0			
*	31.0		5.0	5.0			
		36.5	8.0	7.0			

Axis Option 1

* – Two Statements for Sections with Linearly Varying Stiffness

• – One Statement for Sections with Constant Stiffness

Notes: Sections must be input in order.

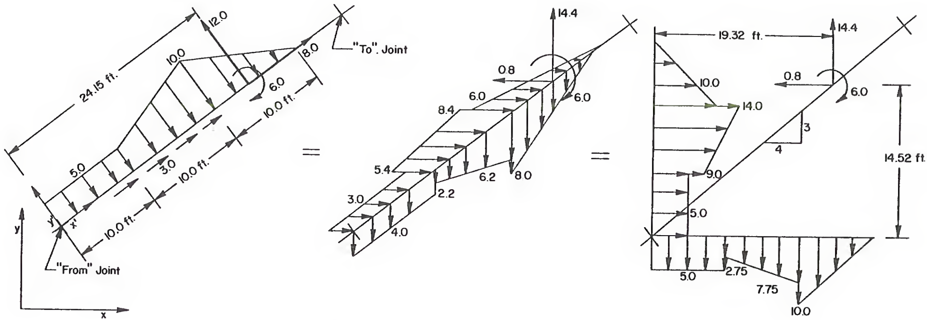
A new section must be started when a change in the variation of any of the stiffness properties occurs.

There is no restriction on the length of a section except it must exceed the length of one of the discrete elements.

"From" and "To" joints are set by input in Table 3C.

Axis Option 2 is used for the rare case where the member restraints act parallel to the structure axes rather than the member axes.

Variable Member Loading



Axis Option 1

	From	To	$Q_{x'},q_{x'x'}$	$Q_{y'},q_{y'x'}$	$Q_{z'},q_{z'x'}$
●	0.0	10.0		-5.0	
*	10.0		3.0	-5.0	
		20.0	3.0	-10.0	
o	24.15	24.15	8.0	12.0	-6.0
*	20.0			-10.0	
		30.0		0.0	

Axis Option 2

From	To	$Q_x,q_{xx'}$	$Q_y,q_{yx'}$	$Q_{z'},q_{z'x'}$
0.0	10.0	3.0	-4.0	
10.0		5.4	-2.2	
	20.0	8.4	-6.2	
24.15	24.15	-0.8	14.4	-6.0
20.0		6.0	-8.0	
	30.0	0.0	0.0	

Axis Option 3

From	To	Q_x,q_{xy}	Q_y,q_{yx}	$Q_z,q_{z'x'}$
0.0	8.0	5.0	-5.0	
8.0		9.0	-2.75	
	16.0	14.0	-7.75	
19.32	19.32	-0.8	14.4	-6.0
16.0		10.0	-10.0	
	24.0	0.0	0.0	

Axis Option 4

From	To	Q_x,q_{xy}	Q_y,q_{yx}	$Q_z,q_{z'x'}$
0.0	6.0	5.0	-5.0	
6.0		9.0	-2.75	
	12.0	14.0	-7.75	
14.52	14.52	-0.8	14.4	-6.0
12.0		10.0	-10.0	
	18.0	0.0	0.0	

o - One Statement for Concentrated Loads

● - One Statement for Sections with Uniform Loads

* - Two Statements for Sections with Linearly Varying Loads

Notes:

There is No Restriction on the Length of a Section Except that it Must Exceed the Length of One of the Discrete Elements.

"From" and "To" Joints Set by Input in Table 3C.

Sections Need Not be Input in Order.

Concentrated Loads May Not be Input at a Distance of 0.0.

APPENDIX D

JOB CONTROL LANGUAGE STATEMENTS

This appendix presents the data sets (files) involved in the FRAME82 analysis of frame structures. FRAME82 analysis requires sequential data sets. The data sets can be stored in either magnetic tapes or direct-access storage devices. However, direct-access storage devices of disk type are recommended for the FRAME82 analysis since they require less access time than the magnetic tapes. Cards may be used for the units that store the hysteretic response of the structure subjected to dynamic loading.

The program, FRAME82, requires four scratch files and three permanent files. Three more permanent files are required if SAVE option is to be specified in the analysis. Cards may be used as the storing device for those additional permanent files, since the member and joint hysteresis output stored in these three units need not be read during the execution.

Scratch files 1, 2, 3, and 4 are used to transfer member results back and forth from the core during a run. This reduces the memory requirements for member results to that of a single member since the results of only one member are held in the core at any time. Cataloged (permanent) files 11, 12, and 13 are used to store the results of the entire frame; i.e. joint and member results. Cataloged files 14, 15, and 16 save member hysteresis at the FROM and TO ends in the direction of original geometry, member responses at the sections near to the FROM

and TO joints in the direction of deformed geometry, and joint displacements and joint shear moments about the z-axis, respectively.

The results are alternatively written on to files 1 and 2, 3 and 4, and 11 and 12 on successive steps so that there will be at least a complete set of good results in the case of convergence or power failure. File 13 keeps the information about which of the two files 11 and 12 contains the latest complete set of good results of the frame analysis.

At the end of each load increment or time step, if a successful solution is obtained (i.e. member and joint solutions satisfy the prescribed equilibrium errors), the member and joint solutions and related quantities are written on to permanent files 11 and 12. Member solutions and related quantities are stored in scratch files 1 and 2. However, the joint information remains within the core and requires an insignificant amount of space compared to that of member information. Therefore, usage of same space parameters is suggested for files 1, 2, 11, and 12. Files 3 and 4 store the indices for various sublayers of the discrete elements and for member support curves to keep track of the occurrence of strain reversal. Since the Input/Output operations are very small, files 3 and 4 do not need large space as files 1 and 2. Nominal size space is adequate for file 13, since it contains only the number of the unit which stores the latest complete set of good results.

Files 14, 15, and 16 are required only if SAVE option is prescribed and their sizes are depended on the number of time steps. Refer to the WRITE statements in subroutines DYNA and DYNAJS to compute the space requirements for these files.

The example problems solved in this study were run on IBM 3081 in conjunction with IBM 3033 and IBM 4341 as supports in a 3 cpu environment. The JCL statements used in Example 9.2 are listed below (6, 47).

```
//EX92 JOB (2006,0800,400,20,0),'V.BALACHANDRAN',CLASS=1,
// REGION=1000K,TYPRUN=HOLD
/*PASSWORD
/*ROUTE
//STEP1 EXEC PGM=FRAME82
//STEPLIB DD DSN=UF.B3060801.S1.FRAME83,DISP=SHR
//FT01F001 DD UNIT=3380,DCB=(RECFM=VBS,BLKSIZE=23476),
// SPACE=(TRK,(03,01),RLSE,CONTIG)
//FT02F001 DD UNIT=3380,DCB=(RECFM=VBS,BLKSIZE=23476),
// SPACE=(TRK,(03,01),RLSE,CONTIG)
//FT03F001 DD DCB=(RECFM=VBS,BLKSIZE=5492,BUFNO=1),
// UNIT=3380,SPACE=(TRK,(02,01),RLSE,CONTIG)
//FT04F001 DD DCB=(RECFM=VBS,BLKSIZE=5492,BUFNO=1),
// UNIT=3380,SPACE=(TRK,(02,01),RLSE,CONTIG)
//FT06001 DD SYSOUT=A,DCB=(RECFM=FA,LRECL=133,BLKSIZE=133)
//FT11F001 DD DSN=UF.B3060801.S1.BALA11,UNIT=3380,
// DISP=(OLD,KEEP),SPACE=(TRK,(03,01),RLSE,CONTIG),
// DCB=(RECFM=VBS,BLKSIZE=23476)
//FT12F001 DD DSN=UF.B3060801.S1.BALA12,UNIT=3380,
// DISP=(OLD,KEEP),SPACE=(TRK,(03,01),RLSE,CONTIG),
// DCB=(RECFM=VBS,BLKSIZE=23476)
//FT13F001 DD DSN=UF.B3060801.S1.BALA13,UNIT=3380,
// DISP=(OLD,KEEP),SPACE=(TRK,(1,1),RLSE,CONTIG),
// DCB=(RECFM=VBS,BLKSIZE=20)
//FT14F001 DD DSN=UF.B3060801.S1.BALA14,DISP=(MOD,CATLG),
// DCB=(DSORG=PS,RECFM=FB,LRECL=80,BLKSIZE=23440),
// UNIT=3380,SPACE=(TRK,(35,05),RLSE,CONTIG)
//FT15F001 DD DSN=UF.B3060801.S1.BALA15,DISP=(MOD,CATLG),
// DCB=(DSORG=PS,RECFM=FB,LRECL=80,BLKSIZE=23440),
// UNIT=3380,SPACE=(TRK,(35,05),RLSE,CONTIG)
//FT16F001 DD DSN=UF.B3060801.S1.BALA16,DISP=(MOD,CATLG),
// DCB=(DSORG=PS,RECFM=FB,LRECL=80,BLKSIZE=23440),
// UNIT=3380,SPACE=(TRK,(16,04),RLSE,CONTIG)
//FT05F001 DD *
/*INCLUDE DATA
CEASE
/*EOJ
```

If the permanent data sets do not exist in the system at time of first run, the files 11 through 16 have to be created using the disposition parameter DISP=(NEW,CATLG). For subsequent runs, disposition parameter needs to be changed to DISP=(OLD,KEEP) for files

11, 12, and 13, and DISP=(MOD,CATLG) for files 14, 15, and 16. Use the following DD statement for files 14 through 16 if the member and joint hysteresis is to be punched on cards.

//FTnnF001 DD SYSOUT=B,DCB=(RECFM=FB,LRECL=80,BLKSIZE=80)

Refer to System/370 Job Control Language by G. E. Brown (6) for further information regarding the JCL statements.

APPENDIX E
GLOSSARY OF FORTRAN VARIABLES IN FRAME82

A	cross-sectional area
AA,AA1-AA4	joint accelerations in SUBROUTINE DYNAJS
AA1,AA2,AA3	joint accelerations in SUBROUTINE DYNA
ACCJT( )	acceleration of joint
AE( )	area times modulus of elasticity
AEL( )	values of AE( ) at edges of sections
AELT	values of AE( ) at left (start) of section
AERT	values of AE( ) at right (end) of section
AETEM( )	temporary location for cumulation of axial stiffness term
AETMP( )	temporary location for cumulation of axial stiffness term
AETT2	value of AE( ) at middle of partial element on right (end) of section
AEY	summation of A*E*Y for all subrectangles
AEYTEM( )	temporary location for cumulation of AEY term
AEYTMP( )	temporary location for cumulation of AEY term
AEY1,AEY2	AEY at first and second discrete rotational springs in element
AEY1	AEY at the hinge of shear element
AE1,AE2	AE( ) at first and second rotational springs in element
AE1	AE( ) for each subrectangle at the hinge of shear element
AG( )	shear area times modulus of rigidity
AG1	modulus of rigidity times shear area at the hinge of shear element
ALBE	DC1*DC2
ALP,ALPH	stiffness degradation factor ALPHA
ALPHA	stiffness degradation factor
ALPHA	relative position of an element
ALPHA( )	stiffness degradation factor for sig-ep curve
ALPHA( )	alphanumeric constants
ALPHJ( )	stiffness degradation factor ALPHA for joint shear stress strain curve
ALS	DC1*DC1
ANEW	alphanumeric constant
ANONE	alphanumeric constant
ANOW	alphanumeric constant
AN1( ),AN2( )	alphanumeric identifiers
APROB	alphanumeric check for dump of temporary prints
B	width of rectangle or outside diameter of pipe
B(,)	element deformation displacement matrix
BCL( )	BI(,) at left or from joint
BES	DC2*DC2
BET	yield stress growth factor BETA
BETA	yield stress growth factor BETA
BETA( )	BETA for a stress strain curve
BETJ( )	stiffness degradation factor BETA for joint shear stress strain curve
BI(,)	width of rectangle or outside diameter of pipe input for x-sect number
BK	slope of member support curve
BM	bending moment
BM,BMS( ),BM1	bending moment at the hinge of the shear element
BML,BMR	bending moment at left and right ends of element
BMOMNL(,), BMOMNR(,)	bending moments at the leftmost and rightmost nonlinear discrete element hinges of monitor member for each time step (leftmost and rightmost linear element hinges for linear member)
BMTEM( )	temporary location for cumulation of bending moment
BMTMP( )	temporary location for cumulation of bending moment
BM1,BM2	bending moments at first and second rotational springs in element
BM1S( ),BM2S( )	stored bending moments at first and second rotational springs of each element in a member
BT(,)	transpose of B(,)
CDAMP( )	damping matrix
CM	contant relating damping matrix and mass matrix
COSCOS	COSI + COSIM1
COSCOS	COS1 + COS2
COSI	cosine of rotation of member at station I
COSIM1	cosine of rotation of member at station IM1
COST	cos(THETA)
COST2	COST*COST
COST3	COST*COST2
COST4	COST2*COST2
COS1	cos(PSI1)
COS2	cos(PSI2)
COS2T	cos(2*THETA)
CUR	curvature
CUR	curvature at the hinge of shear element
CURVAL(,), CURVAR(,)	curvatures at the leftmost and rightmost nonlinear discrete element hinges of monitor member for each time step (leftmost and rightmost linear element hinges for linear member)
CURVAI( )	curvature in discrete shear element
CUR1,CUR2	curvature at first and second rotational springs in element

CURVA1( )	curvature at left hinge of discrete element
CURVA2( )	curvature at right hinge of discrete element
D(,)	element force deformation matrix
DA( )	area of subrectangle
DACCJT( )	incremental acceleration of joint
DAE	AE of subrectangle
DBCL( )	change in BI(,) between from and to joints divided by M
DC(,)	matrix of direction cosines
DCL	DI(,) at left or from joint
DCT(,)	transpose of DC(,)
DC1,DC2	direction cosines
DC1L( ),DC2L( )	direction cosines for load types
DC1S( ),DC2S( )	direction cosines for stiffness types
DD	depth of subrectangle
DDCL( )	change in DI(,) between from and to joints divided by M
DDIS	distances between member output stations
DDX	difference in horizontal displacements of ends of element
DDY	difference in vertical displacements of ends of element
DDZ	difference in rotation of ends of shear element
DEL	length of section of member loading
DELA	axial deformation in shear element
DELAD2	DELA/2.0
DELM	difference in rotation of ends of shear element
DELS	shear deformation in shear element
DELSD2	DELS/2.0
DELTA	axial deformation in element
DELWJT( )	increment of joint displacement
DEPSL( )	change in strain between corresponding points on stress strain curves at from and to joints divided by M
DFFS(,)	incremental dynamic force in either three or four directions at a joint
DFJXT( ),DFJYT( ), DFJZT( ),DFJVT( )	dynamic force increments of x,y,z and v curves
DGL( )	change in GL( ) between from and to joints divided by M
DI(,)	depth of rectangle or thickness of pipe input for X-sect numbers
DIS	distance from the from joint to output station
DISJT(,)	displacements of monitor joint at time step
DITT	alphanumeric constant
DITTO( )	alphanumeric check for same percent increase of member loads
DMM( )	matrix of member end displacements in member coordinates
DMS( )	matrix of member end displacements in structural coordinates
DMS4( )	matrix of member end displacements in 4 DOF structure coordinates
DP	depth of rectangle or thickness of pipe
DQ	slope of linear variation in loading or elastic restraints
DQQ( )	change in force between corresponding points on member support curve at from and to joints divided by M
DQXX( ),DQYY( ), DQZZ( ),DQVV( )	incremental static loads at joint in x,y,z and v directions
DSHCL( )	change in SHCI( ) between from and to joints divided by M
DS	slope of linear stiffness variation
DS(, ,)	matrix D(,) stored for all stations
DSIGL(,)	change in stress between corresponding points on stress strain curve at from and to joints divided by M
DSS1	4.0/DTI
DSS12	2.0/DTI
DSS2	4.0/DTI**2
DT	thrust on one subrectangle
DTE	angle cut out by radial segment of pipe
DTI	time step increment
DVELJT( )	incremental velocities of joints
DWW( )	change in displacement values between corresponding points on member support curves at from and to joints divided by M
DX,DY	X and Y offsets
DX( ),DY( ),DZ( )	member station displacements
DXL( ),DYL( )	X and Y offsets for load types
DXS( ),DYS( )	X and Y offsets for stiffness types
DXX( ),DYY( ), DZZ( ),DVV( )	joint displacements
DXXMJ(,),DYYMJ(,) DZZMJ(,),DVVMJ(,)	displacements stored for monitor joints
DXYZ( )	displacements at all stations (axial, lateral or rotational)
DYCL( )	change in YCL( ) between from and to joints divided by M
DZ1,DZ2	rotations at ends of element
E	modulus of elasticity
EA	AE( )
EI	moment of inertia times modulus of elasticity
EI1,EI2	EI at first and second rotational springs in element
EITEM( )	temporary location to cumulate bending stiffness

EITMP( )	temporary location to cumulative bending stiffness
ELEMN( )	discrete element type
ELEMNT	discrete element type
EM(,)	strain multipliers
EMSCL	scale multiplier for strain axis
ENDFOR(,)	end forces of end elements of member
EP	axial strain
EPA	axial strain in shear element
EPB,EPT	strain at bottom and top of rectangle
EPBFR	bifurcation strain
EPBFRT	temporary value for EPBFR
EPBF1(, ,)	EPBFR at either left hinge of discrete flexural element or the hinge of discrete shear element for a subrectangle, for a component curve
EPBF2(, ,)	EPBFR at right hinge of discrete element for a subrectangle, for a component curve
EPBFT1(, ,)	temporary value of EPBF1
EPBFT2(, ,)	temporary value of EPBF2
EPC( )	strain at centroid of subrectangle
EPPD	strain hardening strain
EPR1S(, ,)	ER at either left hinge of discrete flexural element or the hinge of discrete shear element
EPR2S(, ,)	ER at right hinge of discrete element
EPRT1S(, ,)	temporary value of EPR1S
EPRT2S(, ,)	temporary value of EPR2S
EPS	shear strain in shear element
EPSCOM( )	strain defining components of stress strain curve
EPSIEL(,)	strain defining components of sigma epsilon curve
EPSL(,)	strain values at from or left joint
EPSLON( )	axial strain of center bar of discrete element
EPSLON( )	axial strain in discrete shear element
EPSMAX(, ,)	maximum strain of an element at a hinge at a sublayer of cross section
EPSMIN(, ,)	minimum strain of an element at a hinge at a sublayer of cross section
EPSPRE(, ,)	strain at the end of the previous load or time step of an element at a hinge at a sublayer of cross section
EPSR	strain at to or right joint
EPST( )	strain values for complete stress strain curve at mid-element
EPSTHD( )	strain hardening strain of virgin stress strain curve for mild steel
EPSTS( )	symmetrical portion of EPST( )
EPTT	temporary value of strain
EPULT	ultimate strain of virgin sigma epsilon curve for mild steel
ER	residual strain
ERRLN	error in length of member
ERT	temporary value of ER
ERR1,ERR2	absolute maximum values specified for force and moment joint equilibrium errors
ERX,ERY	error in joint coordinates or member off sets
ERX( ),ERY( ), ERZ( )	station equilibrium errors
ERXX( ),ERYY( ), ERZZ( ),ERVV( )	joint equilibrium errors
ERXXDN( ),ERYYDN( ) ERZZDN( ),ERVVDN( )	contribution of member end forces alone to joint error vector in a dynamic problem
ERXXMJ(,),ERYYMJ(,) ERZZMJ(,),ERVVMJ(,)	joint equilibrium errors at monitor joints
ERXXOL( ),ERYYOL( ) ERZZOL( ),ERVVOL( )	joint equilibrium errors as at the end of last load step
F( )	moment of inertia times modulus of elasticity
FACCJT( )	inertia forces at joints
FDAMJT( )	dynamic force at joint due to damping
FEM( )	member loads (station equlibrium errors)
FF	coeficient in load matrix
FJX,FJY,FJZ,FJV	forces from dynamic force curves
FJXT( ),FJYT( ), FJZT( ),FJVT( )	values of FJX,FJY,FJZ,FJV at joints at the current or previous time step
FL( )	values of F( ) at edges of sections
FLT	value of FL( ) at left (start) of section
FMM( )	member end forces in member coordinates
FMMI( )	incremental member end forces for member
FMMT( )	incremental member end forces due to end station springs in structure direct
FMS( )	member end forces in structure coordinates
FMS4( )	member end forces in 4 DOF structure coordinates
FMT( )	temporary force matrix
FOMOLD(,)	member end forces of last load step
FOMM(,)	member fixed end forces
FOMT( )	member fixed end forces for one member
FORCEL(,), FORCER(,)	axial forces at the leftmost and rightmost nonlinear discrete element hinges of monitor member for each time step (leftmost and rightmost linear element hinges for linear member)
FRMAXF(,),FRMAXD(,) FRMMOM(,),FRMROT(,) FRMSHF(,),FRMLTD(,)	axial force, axial deformation, moment, rotation, shear force, and lateral displacement on left end of monitor members at time steps
FRT	value of F( ) at right (end) of section

FSS( )	structure load matrix
FT( ),FTT( )	temporary force matrices
FTMJXX( ),FTMJYY( ) FTMJZZ( ),FTMJVV( )	scale multipliers for dynamic force curves
FTT2	value of F( ) at middle of partial element on right(end) of section
F1M( ),F2M( )	member end forces at from and to joints in member coordinates
F1S( ),F2S( )	member end forces at from and to joints in structure coordinates
F1S4( ),F2S4( )	member end forces at from and to joints in 4 DOF structure coordinates
G	modulus of rigidity
GA	modulus of rigidity times shear area for each subrectangle
GAMCOM( )	shear strain components of joint shear stress strain curve
GAMIEL(,)	strain component of input joint shear stress strain curve
GAMMA( )	shear strain in discrete shear element
GAMMAL(,), GAMMAR(,)	shear strains at the leftmost and rightmost nonlinear discrete element hinges of monitor member for each time step (leftmost and rightmost linear element hinges for linear member)
GAMMT	strain multiplier for joint tau gamma curve
GAMMLT( )	strain multiplier for joint tau gamma curve
GAMRS(,)	residual shear strain of each masing component at joint
GAMRTS(,)	temporary value of GAMRS(,)
GASTHD( )	strain hardening strain of virgin joint shear strain curve for mild steel
GJ( ),GJT	modulus of rigidity of joint shear panel
GL( )	GS( ) at left or from joint
GS( )	modulus of rigidity corresponding to each member flexural stress strain curve
H	one half of element length
HCU	H*H*H
HC2	H/2
HLJ( ),HLJT	horizontal length of rectangular shear panel, left of the center
HLJ2	HLJ( ) at to end
HPD	H*DELTA
HPDE1I	1/HPD
HPDE2	HPD*HPD
HPDE2I	1/HPDE2
HPDE3I	HPDE2I/HPD
HPR	H+R
HPRC1	HPR*COSIM1
HPRC2	HPR*COSI
HPRE2	HPR*HPR
HPRS	HPR*HPR-S*S
HPRS1	HPR*SINIM1
HPRS2	HPR*SINI
HRJ( ),HRJT	horizontal length of rectangular shear panel, right of the center
HRJ1	HRJ( ) at from end
HS	H*SH
HSI	HS*THDXI
HSQ	H*H
HT	H*TT
HTI	HT*THDXI
IABAN	fatal error flag
IAXOPL( )	axis of option for load types
IAXOPS( )	axis of option for stiffness types
IAXOPT	temporary value of axis option
IBLNK	alphanumeric constant
IC	backward counter
ICOUNT	if equal 0, first section of member linear stiffness data
ICUMU	relative position of sublayer of x-section
IDJ	maximum difference in joint numbers connected by members
ID1,ID2,ID3	dimensions
IE	if equal to 1, element is linearly elastic
IFAE	if equal to 0, call to SUBROUTINES FAEREV AND DETAMS are omitted and stored values are used for thrust, moments and stiffness terms
IHB	(band width of equations - 1)/2
IHBP1	IHB+1
IHB1	IHB-1
IIOVER	alphanumeric constant
IMC ( )	if equal to 1, member did not close
IMJ ( )	if equal to 1, monitor joint
IMM ( )	if equal to 1, monitor member
IM1	I-1
INDEX	switch for setting ER=ERT etc etc =0 not set =1 set
INLOP( ),INLOPT	nonlinear option for member stiffness data
IOPL	IOPOP( ) for last member
IOPOP( ),IOPOPT	member output option
IOVERT	alphanumeric check for overriding percent increese in member loads
IOVRL( )	IOVERT for non-uniform loads
IP	number of equivalent rectangles
IPC	control to print partial member results for three members on one sheet
IPINL( ),IPINLT	pin at left (from) joint option
IPINR( ),INPINRT	pin at right (to) joint option
IP1	I + 1
IP3	I + 3

IP3M	I+3*M
IP3M1	I+3*(M-1)
IP8,IP9,IP10	print options for tables 8,9,10
IR	if equal to 1, element is rigid
IRDYN	see comment after statement number 3400 of SUBROUTINE DYNA
IREAD	the unit (tape, disk etc) number from which the results of the last stored good solution are read in a restart or automatic type analyisis. can be 11 or 12 only
IRECT(,)	if blank, piece is rectangle if equal to 1, piece is pipe
IRSTEP( )	used with IRDYN for reversal alogrithm at a time step analysis
IRV(, ,)	reversal index for element, at hinge, at sublayer, 1=reversal, 0=no reversal
IRVRSE	reversal index for the whole structure #0 reversal occurred at least at one point =1 did not occur
ISJ( )	if equal to 1, joint support curve is symmetrical
ISM ( )	if equal to 1, member support curve is symmetrical
ISS( ),ISST( ), ISSTT	if equal to 1, stress strain curve is symmetrical
IST( ),ISTT	stiffness type
ISTJR( )	stiffness type of member, joint spring is referenced to
ISTP	3*J21+1
ISYM	if equal to 1, curve is symmetrical
ITAPE	=1 tapes N1 and N2 switched as usual =0 not switched, since reversal senced
ITEST1-ITEST4	alphanumeric constants
ITYPE	problem type
IWRITE	the unit (tape, disc etc) number on to which results of latest good solution are to be written; they are alternatively written on units 11 and 12
I1,I2	first and last station inside section
I1PNQ	I1+NQ
I1P1	I1 + 1
J	equation number
JCRGON(,)	region index for joint support curve, yield surface definition similar to NRGION
JCUREV(,)	reversal index for joint support curves in 5 directions (see JCXYZP) =1 reversal occurred, =0 did not occur
JCXYZP	denotes direction of joint support. 1,2,3,4,5 are respectively x,y,z, xprime and yprime directions
JJ	member number
JM1	J - 1
JNTL	error flag for joint number being too large
JOINT( )	joint number
JP3	J + 3
JRGION( )	region index for joint shear stress strain curve; determined from the 1st component; yield surface definition similar to NRGION
JRV( )	reversal index for joint shear stress strain curve =1 reversal occurred =0 reversal did not occur
JSS( )	if equal to 1, joint shear stress strain curve is symmetrical
JST( ),JSTT	joint stiffness type
JST1,JST2	joint stiffness types at from and to joints respectively
JSYES	if JTSHR=JSYES, joint shear is included in the analysis
JT	time step being analyzed
JTL	largest joint number of a member
JTLM1	JTL - 1
JTM	joint number
JTNT	temporary joint number
JTS	smallest joint number of a member
JTSHR	alphanumeric check to include joint shear
JT1( ),JT1T( ),J1, J1I	FROM joint
JT2( ),J2I,J2II	TO joint
J1,J14	equation number
J21	absolute value of difference in joint numbers of members
KASTER	if equal to 1, print asteric by joint to indicate displacement off joint support curve
KEEP2-KEEP7	hold options for tables 2-7
KEKE	check for independent problem
KEY	determines the location of a joint in a frame to select the proper transformation matrix. if =1 horizontal member; from end =2 horizontal member; to end =3 vertical member; from end =4 vertical member; to end
KEYDET	if =1 member is horizontal if =2 member is vertical
KOJ( )	if equal to 1, joint has support curve limit exceeded
KOFFC	if equal to 1, curve displacement or strain limit exceeded

KOFFQW	if equal to 1, member support curve limit exceeded
KOFFSE	if equal to 1, stress strain curve limit exceeded
KOMJ(,)	if equal to 1, monitor joint has support curve limit exceeded
KOUNT	temporary integer variable to count statements
KR,KL	integers for corresponding points on opposite sides of symmetrical stress strain curve
KSETPD	variable used to print identifying and warning message when a run excluding geometric nonlinearities is analyzed
KTEMP	temporary value
LOCAL	see comment in SUBROUTINE ELEMST
LT( ),LTT	load type
LTYPEL	problem type of last problem
L1-L7	dimension limits
L7M1	L7 - 1
L7M2	L7 - 2
L7M3	L7 - 3
M	number of elements in member
MATRL( )	material for a stress strain curve
MATRJ( )	material for joint shear stress strain curve
MCRGON(,)	region index for member support curves; yield surface definition similar to NRGION
MCXYZ	denotes direction of member support curve. 1,2,3 are in the directions of x,y and z respectively
MCUREV(,)	member support curve reversal index at element in 3 directions (see MCXYZ) =1 reversal occured, =0 did not occur
MDJT	maximum value permitted for IDJT
MEMBER	alphanumeric check for dump of iteration details of members
MHB	maximum value pemitted for IHB
MHB1	MHB + 1
MILD	alphanumeric constant
MJ( )	monitor joint member
MJOINT	monitor joint
ML	control for multiple load option
MLOAD( )	number of discrete elements by load type (set internally)
MM( )	monitor member number
MM1	M -1
MNCS	maximum number of cross sections
MNC5	maximum value permitted for NC5
MNC6	maximum value permitted for NC6
MNE	maximum number of elements per member
MNITF	maximum number of frame iterations
MNJS	maximum number of nonlinear joint curves
MNJSS	maximum number of joint shear stress strain curves
MNJST	maximum number of joint stiffness types
MNJT	maximum value permitted for NJT
MNLC	maximum value permitted for NLC
MNLT	maximum value permitted for NLT
MNM	maximum value permitted for NM
MNMM	maximum number of monitor members
MNPCS	maximum number of pieces in cross section
MNPTF	maximum number of points for defining a dynamic force curve
MNQWM	maximum number of member soil support curves
MNST	maximum value permitted for NST
MNSS	maximum number of stress strain curves
MNTSTP	maximum number of time steps that can be analyzed in a single run
MNTST1	MNTSTP + 1
MNTVJL	maximum number of dynamic force curve numbers
MODEL( )	MODELT for stiffness type
MODELT	see comments after statement # 9900 in SUBROUTINE RDMST
MPRINT	=1 member final results printed =0 member final results not printed
MP1	M + 1
MP2	M + 2
MP22	(M + 2)/2
MP221	MP22 - 1
MSSIM1	MSSINL - 1, (also same as maximum number of component curves, if inelastic action to be considered)
MSSINL	maximum number of points (including origin) for defining symmetric part of stress strain curve, if inelastic action to be considered
MSTIF( )	MSTT for stiffness type
MSTT	number of discrete elements for stiffness type
MTRL	material for either member or joint =MILD for special ALPHA-BETA model used consistent with other restraints (see input guide)
NA( )	cross section number
NAGAIN	a variable locally used in SUBROUTINE SECUR for identifying and processing stress strain curves specified with the algorithm for mild steel
NA( ),NALT	area number at from or left joint
NAR( ),NART	area number at to or right joint
NC	curve number

NCDA( ),NCDAT	number of cards that follow describing cross section
NCDL( ),NCDLT	number of cards that follow for load type
NCDS( ),NCDST	number of cards that follow for stiffness type
NCD2-NCD7	number of cards in tables 2-7
NCD3B2	NCD3B/2
NCD5C2	NCD5C/2
NCD5C3	NCD5C/3
NCHECK	= 1 search made to check reversals = 0 reversal not searched
NCOUNT	switch used to print joint curve. definitions for the first time only in SUBROUTINE CURDET
NCR5,NCR6	number of cards read in tables 5 and 6
NC51( ),NC5	number of cards in table 5A above the number of stiffness types (variable stiffness)
NC51T,NC52T	first and last card number of variable stiffness data for member
NC61( ),NC6	number of cards in table 6 above the number of loads types (variable loads)
NC61T,NC62T	first and last card number of variable load data for member
NDIV(,)	NDIVT for x-section, for piece
NDIVT	number of sublayers specified for one input rectangular (or pipe) piece, for inelastic analysis
NE	number of elements which are linearly elastic
NEG	if equal to 1, negative displacement or strain on symmertical curve
NEPS(,),NEPT( )	integer values of strain
NFSUB	switch to choose appropriate FSUB
NFTXX( ),NFTYY( ), NFTZZ( ),NFTVV( )	dynamic force curve number at a joint in x,y,z and v directions respectively
NGAT( )	integer values of strain for joint shear stress strain curve
NGAM(,)	integer values of strain for joint shear stress strain curve
NHINGE	number of hinges in the discrete element; 2 for flexural element; 1 for shear element
NITERF	special variable to keep count of frame iteration, for reversal check algorithm and setting ER=ERT etc etc etc
NITERM( )	special variable to keep count of member iteration, for reversal check algorithm and setting ER=ERT etc etc etc
NITF	number of frame iterations
NITM( )	number of member iterations
NITM1	number of member iterations minus one
NJNC	number of joints not closed
NJNZ	number of non zero joints on data card in tables 2,3
NJSS( )	joint shear stress strain curve number for each joint stiffness type
NJST	number of joint stiffness types
NJT	number of frame joints
NJTT	3 * NJT
NL,NL4	number of simultaneous equations
NLE	NE at left or from joint
NLR	NR at left or from joint
NLR	counter for number of automatic load reductions attempted
NLRA	prescribed maximum number of automatic load reductions to be attempted
NLT	number of load types
NLTL	NLT for last problem
NM	number of frame members
NMJ	number of monitor joints
NMNC	numbner of members not closed
NNP	NN1 + 1
NN1	number of points on stress strain curve on or just below rectangle
NN2	number of points on stress strain curve just above rectangle
NN3	number of subrectangles
NN4	NN3 - 1
NOTE( )	see comment after statement #5900 in SUBROUTINE RDMST
NP	number of points
NPCTOT( )	total number of sublayers in a cross section (restricted to MNPCS)
NPP	number of times FAEJR is called (once for rectangle ten times for pipe)
NPROB	alphanumeric problem number
NPT,NPTT	number of points on curve
NPTJ( )	number of points on joint shear stress strain curve
NPT( )	number of points on joint support curve
NPTM( )	number of points on member support curve
NPTM1	NPT - 1 (also same as number of component curves)
NPM2	= NPTM1 - 1 = NPT - 2
NPTS( ),NPTST	number of points on stress strain curve
NPTV( )	number of points defining a dynamic force curve
NQ	number of elements remaining in section
NQJ(,),NQJT( )	integer values of force on joint support curves
NQM(,),NQMT( )	integer values of force on member support curves
NR	number of elements remaining rigid
NRE	NE at right or to joint
NREAD	= 0 member support curve does not exist # 0 member support curve exists

NRGION(, ,)	region index for strain of element, at hinge, at sublayer of cross-section = 1 positive yield surface (of first component) = 0 fully elastic surface (of first component) =-1 negative yield surface (of first component)
NRR	NR at right or to joint
NSIG(,),NSIT( )	integer values of stress on input curve
NSMJ	specified number of joints to be monitored
NSMM	specified number of members to be monitored
NSS(,)	number of stress strain curve
NSSL( ),NSSLT	number of stress strain curve at left or from joint
NSSR( ),NSSRT	number of stress strain curve at right or to joint
NST	number of stiffness types
NSTL	NST for last problem
NSTORE	intervals of time steps at which results are trasferred to cataloged file 11 or 12
NSXP( ),NSYP( )	number of joint support curve in member x-prime and y-prime directions
NSXL( ),NSYL( ), NSZL( )	number of member support cnrve at from or left joint
NSXR( ),NSYR( ), NSZR( )	number of member support curve at to or right joint
NSXX( ),NSYY( ), NSZZ( ),NSVV( )	joint support curve numbers in structure x,y,z and v directions
NTAT( )	integer values of stress for joint shear stres strain input curve
NTAU(,)	integer values of stress for joint shear stress strain curve
NTI	number of time steps to be analyzed
NTI1	NTI + 1
NTJ(,)	NTJT for a curve
NTJT( )	vector of time abscissae of a dynamic force curve number
NTR	counter for number of automatic time step halvings attempted
NTRA	prescribed maximum number of automatic time step halvings to be attempted
NVL(,)	NVLT for a curve
NVLT( )	vector of force ordinates of a dynamic force curve number
NWJ(,),NWJT( )	integer values of displacement for joint support curves
NWM(,),NWMT( )	integer values of displacement for member support curves
NWRITE	same definition as NREAD
N1	starting index to take advantage of symmetry in forming element stiffness matrix
N1,N2	tapes on which member displacements and memory parameters are alternatively written and read during iteration processes
N3,N4	similar to N1,N2 but only reversal parameters are written and read
N123	control which cycles 1,2,3
N2M1	NCD2 - 1
N3CM1	NCD3C - 1
PCRJL	percent automatic reduction of joint load
PCRML	percent automatic reduction cf member load
PDEL	alphanumeric check for performing analysis excluding geometric nonlinearities
PDELTA	value of PDEL
PDN	alphanumeric constant
PDNO	alphanumeric constant
PRAE( ),PRAET	prismatic AE( )
PRAG( ),PRAGT	prismatic AG( )
PRAT	prismatic area
PRF( ),PRFT	prismatic F( )
PRINT	alphanumeric constant
PRIT	prismatic moment of inertia
PRNTNO	alphanumeric constant
PRSHA	shear area for prismatic member
PSI1,PSI2	rotation at left (start) and right (end) of sections from the line connecting the ends of shear element in the deformed position, respectively
PSLON	yield strain
PUNCH	alphanumeric check for punched output of hysterisis results in a dynamic problem
Q( )	station values for SX,SY,SZ,QX,QY,QZ
QI	concentrated load or spring between stations
QJ	resistive spring force or stress
QJX,QJY,QJZ,QJV	resistive spring forces for nonlinear joint supports
QL,QR	intensity of loading or restraint at left (start) and right (end) of section
QM( )	force multiplier for member support curve
QMJ( )	force multiplier for joint support curve
QO( )	concentrated station load or spring
QQ( )	values of force on support curve or stress strain curve
QQL( )	force values for member support curve at left or from joint

QT1-QT6	loads on member end stations (increment for incremental fixed end force solution, zero for member stiffness matrix solutions and total for evaluation of total end forces on member)
QX( ),QY( ),QZ( )	member station loads
QXL( ),QYL( ), QZL( )	member loads at edges of sections
QXLT,QYLT,QZLT	values of QXL( ),QYL( ),QZL( ) at left (start) of section
QXRT,QYRT,QZRT	values of QXL( ),QYL( ),QZL( ) at right (end) of section
QXX( ),QYY( ), QZZ( ),QVV( )	joint loads
QXXT,QYYT,QZZT,QVVT	temporary values of QXX( ), QYY( ), QZZ( ), QVV( )
Q1,Q2	intensity of loading or restraints at beginning and end of element
R	difference in axial displacement between discrete rotational hinges in element
R	switch (if equal to +1 negative curvature, if equal to -1 positive curvature)
R	resistance of member support curve or joint support curve
RA	mean radius of pipe
RM(,),RO( )	recursion multipliers
RMAX( )	charestertistic resistance defining component of member or joint support curve
RMAXJT(,)	RMAX for support curve at joint
RMAXMI(,)	RMAX for member support curve at the center of a discrete element
RXX( ),RYY( ), RZZ( ),RVV( )	joint reactions
S	difference in lateral displacement between discrete rotational springs in element
SA(,)	stiffness matrix used for member springs in structure coordinates
SC1	S*COSIM1
SC2	S*COSI
SEEE(,)	see comments in subroutines MEMENI and ELEMST
SEET(,)	element stiffness matrix (6X6)
SEE3(,)	3X3 portion of SEET(,)
SEM(,)	3X6 member stiffness matrix used in member solutions - composed of 3X3 submatrices of element stiffness matrix
SEMS(,)	3X3 portion of SEM stored for element IP1 while forming SEM for station I
SE2	S*S
SH,SHS( ),SH1	shear force at the hinge of the shear element along the deformed axis
SHC(,)	shear area coefficient
SHCL( )	shear area coefficient at left or from end
SHCOEF	shear area coefficient at mid-element
SHEAR	alphanumeric constant to include discrete shear element model
SHFORL(,), SHFORR(,)	shear forces at the leftmost and rightmost nonlinear discrete element hinges of monitor member for each time step (leftmost and rightmost linear element hinges for linear member)
SHMO( )	joint shear moment
SHMOJ	joint shear moment
SHMOJT(,)	joint shear moment of monitor joints at time steps
SIG	stress at centroid of subrectangle
SIGCOM( )	charesteristic stress of component
SIGHIS( )	history dependent stress at hinge for a sublayer
SIGL(,)	stress values for stress strain curve
SIGMA	yield stress of a component curve
SIGMAX(,)	stress defining components of sigma epsilon curve at left or from joint
SIGR	stress at right or to joint
SIGT( )	stress values for complete stress strain curve at mid-element
SIGTS( )	symmetrical part of SIGT( )
SIGULT( )	SULT for a curve number
SINI	SIN of rotation at station I
SINIM1	SIN of rotation at station IM1
SINSIN	SINI + SINIM1
SINSIN	SIN1 + SIN2
SINT	sin(THETA)
SIN1	sin(PSI1)
SIN2	sin(PSI2)
SIN2T	sin(2*THETA)
SIN2T2	SIN2T*SIN2T
SJC( ),SJCT	joint constant to calculate joint shear moment and stiffness
SJX,SJY,SJZ,SJV	tangent spring stiffnesses of joint supports
SJXY	off-diagonal stiffness term for joint spring referenced to member coordinates
SL( )	vector of stiffness matrix
SLBFR	the smaller stiffness at bifurcation point
SLBFRT	temporary value of SLBFR
SLBF1(, ,)	SLBFR at either left hinge of discrete flexural element or the hinge of discrete shear element for a subrectangle, for a component curve

SLBF2(, ,)	SLBFR at right hinge of discrete element for a component curve
SLBFT(, ,)	temporary value of SLBF1
SLBF2(, ,)	temporary value of SLBF2
SLHD	strain hardening slope
SLOPHD( )	SLHD for a curve number
SLOK,SLOKP1	slopes of adjacent line segments of virgin curve
SLPHDJ( )	strain hardening slope for joint shear stress strain curve
SLPMAX	maximum slope (at origin) of virgin curve
SM(,)	stress multipliers for stress strain curve
SMALJ	slope of line right of yield point of joint shear stress strain curve for mild steel
SMALL	slope of line right of yield point of the stress strain curve for mild steel
SMC(,)	member stiffness matrices in compact form
SMLSLJ( )	value of SMALJ for a curve number
SMLSLP( )	value of SMALL for a curve number
SMM(,)	member stiffness matrix (3X3) in member coordinates
SMSCL	scale multiplier for stress axis
SMT( )	single members stiffness matrix in compact vector form
SMS	member stiffness matrix (3X3) in structure coordinates
SMS3(,)	member stiffness matrix in 3 DOF structure coordinates
SMS4(,)	member stiffness matrix (4X4) in 4 DOF structure coordinates
SQX( ),SQY( ), SQZ( )	resistive spring forces for nonlinear station springs
SQXYZ( )	resistive spring forces for all stations (axial, lateral or rotational)
SSL	structure stiffness matrix of either 3X3 or 4X4 (diagonal submatrix and those to right)
SS1	S*SINIM1
SS2	S*SINI
ST( )	station value of stiffness
STA,STB	stiffness (AE or F) at start and end of element or piece of element
STEEP( )	SLPMAX for member support curve number
STF	elastic stiffness of component
STFHIS	history dependent joint shear stiffness
STFHIS( )	history dependent stiffness at hinge for a sublayer
STFJ	joint shear stiffness
STL,STR	stiffness at left (start) and right (end) of section
STRAIN	strain at a point
STRANL(,), STRANR(,)	axial strains at the leftmost and rightmost nonlinear discrete element hinges of monitor member for each time step (leftmost and rightmost linear element hinges for linear member)
STRESS	stress at a point
STT1,STT2	stiffness at mid points of partial elements at beginning and end of adjacent sections
ST1-ST6	restraint at member end stations
SULT	ultimate stress
SX( ),SY( ),SZ( )	nonlinear member station restraints
SXL( ),SYL( ), SZL( )	values of SX( ),SY( ),SZ( ) at edges of sections
SXLT,SYLT,SZLT	values of SXL( ),SYL( ),SZL( ) at left (start) of section
SXRT,SYRT,SZRT	values of SXL( ),SYL( ),SZL( ) at right (end) of section
SXT,SYT	temporary storage values for SX( ) and SY( )
SXX( ),SYY( ), SZZ( ),SVV( )	linear joint restraints
SXXT,SYYT,SZZT,SVVT	temporary values of SXX( ), SYY( ), SZZ( ), SVV( )
SXYZ( )	spring stiffness for all stations (axial, lateral or rotational)
S0	stress on path of component curve
S2	negative slope of curve
T	thickness of pipe
T	thrust
TAUCOM( )	shear stress components of joint shear stress strain curve
TAUHIS	history dependent joint shear stress
TAUMAX(,)	stress components of input joint shear stress strain curve
TAUMLT( )	stress multiplier for joint tau gamma curve
TAUMT	stress multiplier for joint tau gamma curve
TAUULT( )	ultimate shear stress for joint shear stress strain curve
TAU1,TAU2	discrete angle changes at first and second discrete rotational springs in flexural element
TE	angle from top of pipe to center of radial segment
TEMP1,TEMP2	temporary values
TEMP0	temporary value of EPSMIN for a component subject to not more than the negative of the characteristic strain of the component

TH	element length
THDX	deformed length of shear element along original geometry
THDXI	1/THDX
THDXI2	THDXI*THDXI
THETA	angle axially deformable bar in element makes with member x-prime axis
THETA	angle between the line joining the deformed ends of the shear element and member x-prime axis
THKJ( ),THKJT	thickness of joint shear panel
THMNJT	3*MNJT
TIME	time corresponding to time step being analyzed
TL,TR	thrust at left and right ends of element
TM(,)	temporary matrix to store portions of element stiffness matrix due to initial forces (initial stress matrix)
TMESTP	alphanumerical variable internally set to denote present and next time steps in a dynamic problem and none in a static problem
TOAXF(,),TOAXD(,)	axial force, axial displacement,
TOMOM(,),TOROT(,)	moment, rotation, shear force and
TOSHF(,),TOLTD(,)	lateral displacement on right end of monitor members at time steps
TOL	joint location tolerance
TOTTME	total time range for dynamic analysis
TRD(,)	matrix TRD when transforms member diagonal stiffness matrix
TRDT(,)	transpose of matrix TRD
TRM(,)	transforms member stiffness and load matrices from 3 DOF to 4 DOF in structure coordinates
TRO(,)	matrix TRM when transforms member off-diagonal stiffness matrix
TT	axial thrust in axially deformable center bar in element
TT,TTS( ),TT1	thrust at the hinge of shear element along deformed axis
TTEM( )	temporary location for cumulation of axial force on cross section
TTHETA	tan(THETA)
TTM	TT*HPDE3I
TTMHO2	TTM*HO2
TTMJ( )	time scale of dynamic force curve number
TTMP( )	temporary location for cumulation of axial force on cross section
TTOL	2*TOL
TTS( )	thrust in element stored for all elements
TTSLEF,TTSRGT	see comments after statement # 4100 in SUBROUTINE FAEREV
T1,T2	thrust at first and second rotational springs in flexural discrete element
T33	temporary matrix used to obtain triple product
T43(,)	temporary matrix used in matrix multiplication
U	deformation with which joint or member support curve is entered for computing resistance and stiffness
UQX( ),UQY( )	uniform member loads
UQXT,UQYT	temporary values of UQX( ), UQY( )
UR( )	residual deformation of component of joint or member support curve
URT( )	temporary value of UR
U1( ),U2( )	axial forces on end of elements
U1T,U2T	axial forces on ends of element
U1TT( ),U2TT( )	axial forces on ends of elements. also see comments in SUBROUTINES ELEMST and FORMLD
V	shear
VELJT( )	joint velocity
VL,VR	shear at left and right ends of element
VLJ( ),VLJT	vertical length of rectangular joint shear panel, below center
VLJ2	VLJ( ) at to end
VT	shear force in axially deformable center bar in flexural element
VTM	VT*HPDE3I
VTMHO2	VTM*HO2
VUJ( ),VUJT	vertical length of rectangular joint shear panel, above center
VUJ1	VUJ( ) at from end
VV,VV1-VV4	velocities at joint in SUBROUTINE DYNAJS
VV4,VV5,VV6	three velocities at joint in SUBROUTINE DYNA
V1( ),V2( )	shear forces on ends of elements
V1T,V2T	shear forces on ends element
V1TT( ),V2TT( )	shear forces on ends of elements. also see comments in SUBROUTINES ELEMST and FORMLD
W( )	vector of displacement increments from SUBROUTINE GRIP2A
W( )	chracteristic deformation defining the component of joint or member support curve
WJ	displacement or stress
WM( )	displacement multiplier for member support curves
WMJ( )	displacement multiplier for joint support curves
WRM( )	residual deformations of components of member support curves
WRTM( )	temporary value of WRM

WRTX(,),WRTY(,), WRTZ(,),WRTV(,), WRTXP(,),WRTYP(,)	temporary values of the corresponding variables
WRTXM(,),WRTYM(,), WRTZM(,)	temporary values of coresponding variables
WRX(,),WRY(,), WRZ(,),WRV(,), WRXP(,),WRYP(,)	residual deformations of joint support curve components, at joint, in x,y,z,v, xprime and yprime directions
WRXM(,),WRYM(,), WRZM(,)	residual deformations of components of member support curves at center of element
WT( ),W1T( )	temporary displacement matrices
WW( )	values of displacement on support curve or stress strain curve
WWJT(,)	W( ) for joint support curve number
WWL( )	displacement values for member support curve at from or left joint
WWMI(,)	W( ) for member support curve at the center of element
W1( ),W2( )	moments on ends of elements
W1T,W2T	bending moments on ends of element
W1TT( ),W2TT( )	bending moments on ends of elements. also see comments in SUBROUTINES ELEMST and FORMLD
X( ),Y( )	joint coordinates
XL	distance to left (start) of section
XLL( )	distance to left (start) of load section
XLS( )	distance to left (start) of stiff section
XR	distance to right (end) of section
XRL	distance to right (end) of load section
XRS( )	distance to right (end) of stiff section
XT,YT	temporary joint coordinates
XX	distance to station on left of concentrated load from the FROM joint
X1,X2	length of partial elements at ends of sections
X2L	X2 from last section
Y	distance from centroid of subrectangle to member x-prime axis
YB,YT	Y distance to bottom and top of rectangle
YC	distance from centroid of pipe to member x-prime axis
YCL( )	Y(,) at left or from joint
YGR	updated yield stress level due to strain hardening of mild steel
YGROW(, ,)	YGR for element, at hinge, at a sublayer
YI(,)	centroidal distance input for x-section number
YTGR	temporary value of YGR
YTGROW(, ,)	temporary value of YGROW
YTT	temporary Y distance
YY( )	Y distance for subrectangle
Z	distance to concentrated load from station on left
Z	resistance of component of joint or member support curve
Z	border strain between certain regions of stress strain path (see SUBROUTINE DEGROW)
ZI	floating point I
ZIP	floating point IP
ZI1,ZI2	floating point I1 and I2
ZL	member length
ZLL( )	length of members by load type
ZLS( )	length of members by siffness type
ZL2	ZL*ZL
ZL3	ZL2*ZL
ZMASSR( )	mass at joint
ZMUL	ratio of length to mid-length to member total length
ZZ	distance from station on left to the concentrated load or spring

APPENDIX F
FORTRAN LISTING OF FRAME82

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COMMENT - MAIN PROGRAM OF FRAME82
      IMPLICIT REAL*8 (A-H,O-Z)
      REAL*8 JTSHR
      REAL*4 DISJT
      REAL*4 FORCEL, STRANL, BMOMNL, CURVAL, SHFORL, GAMMAL,
     2       FORCER, STRANR, BMOMNR, CURVAR, SHFORR, GAMMAR,
     3       FRMAXF, FRMAXD, FRMMCM, FRMROT, FRMSHF,FRMLTD,
     4       TOAXF,  TOAXD,  TOMCM,  TCROT,  TOSHF, TOLTD,
     5       SHMJT
COMMENT - THIS DRIVER ONLY DIMENSIONS PROGRAM
COMMENT - TO CHANGE DIMENSIONS CHANGE ONLY THIS DRIVER AND DIMENSIONED
COMMENT - COMMON BLOCKS IN APPROPRIATE SUBROUTINES
COMMENT - VARIABLE NAMES DO NOT CHANGE IN DIMENSIONED COMMON BLOCKS
COMMENT - *********************** DIMENSION GUIDE **********************
COMMENT - RM(L6,L4)          RO(L6)            W(L6)
COMMENT - DELWJT  (4*MNJT)
COMMENT - COMMON BLOCK1(MNJT)          BLOCK2(MNST)          BLOCK3(MNLT)
COMMENT - COMMON BLOCK4(MNM)           BLOCK5(MNC5)          BLOCK6(MNC6)
COMMENT - COMMON BLOCK7(L1)            BLOCK8(MNJS)          BLOCK9(MNPCS)
COMMENT - COMMON BLOC1  (MNJT)
COMMENT - COMMON BLOC10(4,L4)          BLOC12(MNCS,MNPCS)  BLOC13(MNSS)
COMMENT - COMMON BLOC14(MNOWM)         BLOC16(MNJT)
COMMENT - COMMON BLOC21(4*MNJT)   &  (4*MNMJ,MNTST1)
COMMENT - COMMON BLOC22(MNJT)          BLOC23(3,MNJT)
COMMENT - COMMON BLK9    (MNTVJL,MNPTF)
COMMENT - COMMON BLCK1   (MNJT)
COMMENT - COMMON SKT1(MNJS,10)         SKT2(MNJT,10)
COMMENT - COMMON SKT5    (MNE1,10)     SKT6    (MNM)
COMMENT - COMMON SKT7(MNE1)            SKT9(MNM,6)
COMMENT - COMMON SKT10(MNCS,MNPCS)  SKT12(MNSS,MSSIM1)
COMMENT - COMMON SKT13(MNE1,MNPCS,MSSIM1)
COMMENT - COMMON SKT14  (MNE1,2,MNPCS)   &   (MNM,6)
COMMENT - COMMON SKT16  (MNJT)         SKT19  (MNJT,5)       SKT20  (MNE1,3)
COMMENT - COMMON SKT22  (MNTST1)       SKT28  (MNMM,MNTST1)  SKT29  (L1)
COMMENT - COMMON SKT30(MNST)&(MNLT)                          SKT31  (MNSS)
COMMENT - COMMON SKT32  (MNE1,MNPCS,MSSIM1) & (MNE1,2,MNPCS)
COMMENT - COMMON SKT33  (MNE1,2,MNPCS)                       SKT34  (MNJT)
COMMENT - ***************************************************************
      DIMENSION RM(100,24),RO(100),W(100)
      DIMENSION DELWJT (100)
      COMMON /DBLK1/KEEP4C,NCD4D,KEEP4E,NCD4E
      COMMON /DBLK3/ MNTVJL
      COMMON /BLOCK1/ X(25),       Y(25),       QXX(25),     QYY(25),
     2    QZZ(25),     SXX(25),     SYY(25),     SZZ(25),     DXX(25),
     3    DYY(25),     DZZ(25),     RXX(25),     RYY(25),     RZZ(25),
     4    ERXX(25),    ERYY(25),    ERZZ(25),    QMJ(25),     WMJ(25),
     5    NSXX(25),    NSYY(25),    NSZZ(25),    IMJ(25),     NSXP(25),
     6    NSYP(25),    ISTJR(25)
      COMMON /BALA01/ QVV(25),     SVV(25),     DVV(25),     ERVV(25),
     2    RVV(25),     NSVV(25)
      COMMON /BLOCK2/ DXS( 25),    DYS( 25),    ZLS( 25),    DC1S( 25),
     2    DC2S( 25),   PRF( 25),    PRAE( 25),   QM( 25),     WM( 25),
     3    PRAG(25),    ELEMN(25),
     4    IOPOP( 25),  IPINL( 25),  IPINR( 25),  NC51( 25),   INLOP( 25),
     5    NAL( 25),    NSXL( 25),   NSYL( 25),   NSZL( 25),   NAR( 25),
     6    NSXR( 25),   NSYR( 25),   NSZR( 25),   NCDS( 25),   IAXCPS( 25)
      COMMON /BALA02/ JST(25),NJSS(25),HLJ(25),HRJ(25),VLJ(25),VUJ(25),
     2    THKJ(25),GJ(25),SJC(25)
      COMMON /BLOCK3/ DXL( 25),    DYL( 25),    ZLL( 25),    DC1L( 25),
     2    DC2L( 25),   UQX( 25),    UQY( 25),    NCDL( 25),   IAXOPL( 25),
     3    NC61( 25),   IOVRM(25)
      COMMON /BLOCK4/ FOMM(50,6),SMC(50,21),IST(50),   LT(50),
     2    JT1(50),     JT2(50),     NITM(50),    IMM(50),     IMC(50)
      COMMON /BLOCK5/ XLS( 50),    XRS( 50),    FL( 50),     AEL( 50),
     2    SXL( 50),    SYL( 50),    SZL( 50)
      COMMON /BLOCK6/ XLL( 75),    XRL( 75),    QXL( 75),    QYL( 75),
     2    QZL( 75),    IOVRL(75)
      COMMON /BLOCK7/ F( 22),      AE( 22),     SX( 22),     SY( 22),
     2    SZ( 22),     QX( 22),     QY( 22),     QZ( 22),     DX( 22),
     3    DY( 22),     DZ( 22),     ERX( 22),    ERY( 22),    ERZ( 22),
     4    SQX( 22),    SQY( 22),    SQZ( 22),    U1( 22),     V1( 22),
     5    W1( 22),     U2( 22),     V2( 22),     W2( 22),     DS(3,3, 22),
     6    BM1S( 22),   BM2S( 22),   TTS( 22),    AG( 22)
      COMMON /BLOCK8/ NPT( 20),    ISJ( 20),    NQJ( 20,11),NWJ( 20,11),
     2    NQJT(11),    NWJT(11)
      COMMON /BALA09/ GL(10),      DGL(10),     SHCL(10),    DSHCL(10)
      COMMON /BLOCK9/ BCL(10),     DBCL(10),    DCL(10),     DDCL(10),
     2    YCL(10),     DYCL(10),    SIGL(10,11), EPSL(10,11),DSIGL(10,11),
     3    DEPSL(10,11),ISST(10),    NSSL(10),    NSSR(10)
      COMMON /BLOC1/ ZMASS(25),FTMJXX(25),FTMJYY(25),FTMJZZ(25),
     2    FTMJVV(25),TTMJ(25),NFTXX(25),NFTYY(25),NFTZZ(25),NFTVV(25)
      COMMON /BLOC10/ SSL(4,24)
      COMMON /BLOC11/ SEET(6,6)
      COMMON /BALA12/ SHC(20,10)
      COMMON /BLOC12/ SM(20,10),   EM(20,10),   BI(20,10),   DI(20,10),
     2    YI(20,10),   NSS(20,10), NA(20),      NCDA(20),    IRECT(20,10)
      COMMON /BALA13/ GS(08)
      COMMON /BLOC13/ NPTS( 08),   ISS( 08),   NSIG(08,11),NEPS(08,11),
     2    NSIT(11),    NEPT(11)
      COMMON /BLOC14/ NPTM( 20),   ISM( 20),   NQM(20,11), NWM(20,11),
     2    NQMT(11),    NWMT(11)
      COMMON /BLOC15/ EPST(21),    SIGT(21),    EPSTS(11),   SIGTS(11)
      COMMON /BLOC16/ ERXXMJ(5,25),ERYYMJ(5,25),ERZZMJ(5,25),
     2    DXXMJ(5,25),DYYMJ(5,25),DZZMJ(5,25),KOMJ(5,25),KOJ(25)
      COMMON /BALA16/ ERVVMJ(5,25),DVVMJ(5,25)
      COMMON /BLOC21/ ACCJT(100),VELJT(100),ZMASSR(100),DACCJT(100),
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     2    DVELJT(100),FACCJT(100),FDAMJT(100),CDAMP(100),DISJT(80,71)
      COMMON /BLOC22/ FJXT(25),FJYT(25),FJZT(25),FJVT(25),
     2    DFJXT(25),DFJYT(25),DFJZT(25),DFJVT(25)
      COMMON /BLOC23/ DFFS(4,25)
      COMMON/BLOC24/   AN1(40),AN2(11),NPROB(2)
      COMMON /BLK1/  TOL,     ELEMNT,NJST,   KEEP3C,NCD3C,
     2          KEEP2, KEEP3A,KEEP3B,KEEP4A,KEEP4B,KEEP4C,KEEP5A,
     3          KEEP5B,KEEP5C,KEEP5D,KEEP6, KEEP7, NCD2,  NCD3A,
     4          NCD3B, NCD4A, NCD4B, NCD4C, NCD5A, NCD5B, NCD5C,
     5          NCD5D, NCD6,  NCD7,  IP8,   IP9,   IP10,  ITYPE,
     6          IABAN, IFORM, NM,    NJT,   NST,   NLT,   M,
     7          MP1,   MP2,   ISTT,  LTT,   ITYPEL,IDJ,   NSTL
      COMMON /BLK2/ XL,XR,X1,X2,              H,TH,HSQ,HCU,X2L,I1,I2,NQ
      COMMON /BLK3/ MNJT,MNST,MNLT,MNM,MNC5,MNC6,MDJT,MNJS,MNE,MNCS,
     2    MNPCS,MNSS,MNQEM,MNJST,MNJSS
      COMMON /BLK4/ ST1,ST2,ST3,ST4,ST5,ST6
      COMMON /BLK5/ NFSUB,NITF,N1,N2
      COMMON /BLK6/ QT1,QT2,QT3,QT4,QT5,QT6
      COMMON /BLK7/ INLOPT,IFAE,KCFFJ,KOFFQW,KOFFSE
      COMMON /BLK8/ NLTL
      COMMON/BLK9/  NVL(20,300),   NTJ(20,300),   NVLT(300),
     2             NTJT(300) ,     NPTV(20) ,    MNPTF
      COMMON / RI / NL, ML, J1
      COMMON/ITC/  ERR1,ERR2,ER1,ER2,DTI,CM,NTI,MM(20),MJ(20),MNITF,
     2             MNITM,NSMJ,NSMM
      COMMON /WARN/ NJNC,NMNC
      COMMON / NIT/ APROB
      COMMON / BR / PCRML, PCRJL, NLR, NLRA
      COMMON /BLOK1/ DQXX(25), DQYY(25), DQZZ(25), DQVV(25)
      COMMON /SKT1/          WWJT(20,10),     RMAXJT(20,10)
      COMMON /SKT2/       WRX(25,10),   WRY(25,10),   WRZ(25,10),
     2    WRV(25,10),   WRXP(25,10), WRYP(25,10), WRTX(25,10),
     3    WRTY(25,10),  WRTZ(25,10), WRTV(25,10), WRTXP(25,10),
     4    WRTYP(25,10)
      COMMON /SKT3/ NCCUNT, NITERF
      COMMON /SKT5/          WRXM (21,10),  WRYM (21,10),  WRZM (21,10),
     2                       WRTXM(21,10),  WRTYM(21,10),  WRTZM(21,10)
      COMMON /SKT6/          NITERM(50), INDEX
      COMMON /SKT7/          U1TT(21),      V1TT(21),      W1TT(21),
     2                       U2TT(21),      V2TT(21),      W2TT(21)
      COMMON /SKT8/          SEEE(6,6)
      COMMON /SKT9/          ENDFOR(50,6)
      COMMON /SKT10/         NDIV(20,10),   NPCTOT(20)
      COMMON /SKT11/         MSSINL,        MSSIM1
      COMMON /SKT12/         EPSIEL(08,03), SIGMAX(08,03)
      COMMON /SKT13/         EPR1S(21,10,3),EPRT1S(21,10,3),
     2                       EPR2S(21,10,3),EPRT2S(21,10,3)
      COMMON /SKT14 / IRV(21,2,10),                      FOMOLD(50,6),
     2                IRVRSE,        ITAPE,              N3
      COMMON /SKT15/  JJ
      COMMON /SKT16/      ERXXOL(25),ERYYOL(25),ERZZCL(25),ERVVOL(25)
      COMMON /SKT17/  N4
      COMMON /SKT18/ NCHECK
      COMMON /SKT19/ JCRGCN(25,6), JCUREV(25,6)
      COMMON /SKT20/ MCRGCN(21,3), MCUREV(21,3)
      COMMON /SKT21/ NTR, NTRA
      COMMON /SKT22/ TIME, JT, IRDYN, IRSTEP(71)
      COMMON /SKT23/ PDELTA
      COMMON /SKT25/ TTSLEF, TTSRGT, NLE, NRE
      COMMON /SKT26/ LTYPEL
      COMMON /SKT27/ IREAD, IWRITE
      COMMON /SKT28/ FORCEL(20,71),STRANL(20,71),BMOMNL(20,71),
     2    CURVAL(20,71),FORCER(20,71),STRANR(20,71),BMOMNR(20,71),
     3    CURVAR(20,71),FRMAXF(20,71),FRMAXD(20,71),FRMMOM(20,71),
     4    FRMROT(20,71),FRMSHF(20,71),FRMLTD(20,71),TOAXF(20,71),
     5    TCAXD(20,71), TOMOM(20,71), TORCT(20,71), TOSHF(20,71),
     6    TOLTD(20,71)
      COMMON /SKT29/ EPSLON(22), CURVA1(22), CURVA2(22)
      COMMON /SKT30/ MSTIF(25), MLOAD(25), MCDEL(25)
      COMMON /SKT31/ ALPHA  (8), BETA  (8), SMLSLP(8), EPSTHD(8),
     2               SLOPHD (8), SIGULT(8), MATRL  (8)
      COMMON /SKT32/ EPBF1  (21,10,3), EPBFT1(21,10,3), SLBF1 (21,10,3),
     2               SLBFT1(21,10,3), EPBF2  (21,10,3), EPBFT2(21,10,3),
     3               SLBF2  (21,10,3), SLBFT2(21,10,3),
     4               EPSMAX (21,2,10), EPSMIN(21,2,10), EPSPRE(21,2,10),
     5               YGROW  (21,2,10), YIGROW(21,2,10)
      COMMON /SKT33/ NRGION(21,2,10)
      COMMON /SKT34/ ERXXDN(25), ERYYDN(25), ERZZDN(25), ERVVDN(25)
      COMMON /SKT35/ TMESTP
      COMMON /GT/ MJO
      COMMON /CHAN1/ JTSHR
      COMMON /CHAN2/ SHMC(25)
      COMMON /CHAN13/ NPTJ( 08),   JSS( 08),  NTAU(08,08),NGAM(08,08),
     2    NTAT(08),     NGAT(08),TAUMLT(08),GAMMLT(08)
      COMMON /CHA12/       GAMIEL(08,03), TAUMAX(08,03)
      COMMON /CHA13/ GAMRS(25,3),GAMRTS(25,3)
      COMMON /CHA19/ JRV(25),JRGION(25)
      COMMON /CHA28/ SHFORL(20,71),GAMMAL(20,71),SHFORR(20,71),
     2    GAMMAR(20,71),SHMJT(20,71)
      COMMON /CHA31/ ALPHJ  (8), BETJ   (8), SMLSLJ(8), GASTHD(8),
     2               SLPHDJ(8), TAUULT(8), MATRJ  (8)
      CALL      ERRSET ( 208,256,-1,1,1,208 )
                MNJT =   25
                MNJST= 25
                MNM  =   50
                MNMJ = 20
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            MNMM =  20
            MNST =  25
            MNLT =  25
            MNC5 =  50
            MNC6 =  75
            MDJT = 5
            MHB = 4*MDJT + 3
            MNE = 20
            MNJS = 20
            MNJSS = 8
            MNCS = 20
            MNPCS = 10
            MNSS =  8
            MNTVJL =20
            MNPTF  = 300
            MNTSTP = 70
            MNTST1 = MNTSTP + 1
            MNQWM  = 20
            MSSINL = 4
            MSSIM1 = MSSINL - 1
            MNE1 = MNE + 1
            L1 = MNE + 2
            L2 = 3*MNE1
            L3   =  MHB
            L4   =  MHB + 1
            L5 = 3*L1
            L6 = 4*MNJT
      IF (L6 .LT. L5) L6=L5
            L7 = 3*L1 + 1
COMMENT - SUBROUTINE STATIC IS THE MAIN SUBROUTINE OF PROGRAM FRAME63
COMMENT - AND PERFORMS SIMPLE INPUT, OUTPUT, AND COMPUTATIONAL FUNCTIONS
      CALL       STATIC ( RM, RO, W, SL, L1, L2, L3, L4, L6,DELWJT)
      STOP
      END


 ********************************** SUBROUTINE **********************************
      SUBROUTINE STATIC (RM, RO, W, SL, L1, L2, L3, L4,L6,DELWJT)
COMMENT - SUBROUTINE STATIC IS THE MAIN SUBROUTINE OF PROGRAM FRAME82
COMMENT - STATIC CALLS PRIMARY INPUT, OUTPUT,AND COMPUTATION SUBROUTINES
COMMENT - AND PERFORMS STATIC ANALYSIS.
      IMPLICIT REAL*8 (A-H,O-Z)
      REAL*8 MEMBER
      REAL*8 JTSHR,JSYES
      DIMENSION SMMT(21),FOMT(6)
      DIMENSION RM(L6,L4), RO(L6), W(L6)
      DIMENSION DELWJT ( L6 )
      COMMON /DBLK1/KEEP4D,NCD4D,KEEP4E,NCD4E
      COMMON /DBLK3/ MNTVJL
      COMMON /BLOCK1/ X(25),        Y(25),        QXX(25),      QYY(25),
     2    QZZ(25),      SXX(25),      SYY(25),      SZZ(25),      DXX(25),
     3    DYY(25),      DZZ(25),      RXX(25),      RYY(25),      RZZ(25),
     4    ERXX(25),     ERYY(25),     ERZZ(25),     QMJ(25),      WMJ(25),
     5    NSXX(25),     NSYY(25),     NSZZ(25),     IMJ(25),      NSXP(25),
     6    NSYP(25),     ISTJR(25)
      COMMON /BALA01/ QVV(25),      SVV(25),      DVV(25),      ERVV(25),
     2    RVV(25),      NSVV(25)
      COMMON /BLOCK2/ DXS( 25),     DYS( 25),     ZLS( 25),     DC1S( 25),
     2    DC2S( 25),    PRF( 25),     PRAE( 25),    QM( 25),      WM( 25),
     3    PRAG(25),     ELEMN(25),
     4    IOPOP( 25),   IPINL( 25),   IPINR( 25),   NC51( 25),    INLOP( 25),
     5    NAL( 25),     NSXL( 25),    NSYL( 25),    NSZL( 25),    NAR( 25),
     6    NSXR( 25),    NSYR( 25),    NSZR( 25),    NCDS( 25),    IAXOPS( 25)
      COMMON /BALA02/ JST(25),NJSS(25),HLJ(25),HRJ(25),VLJ(25),VUJ(25),
     2    THKJ(25),GJ(25),SJC(25)
      COMMON /BLOCK3/ DXL( 25),     DYL( 25),     ZLL( 25),     DC1L( 25),
     2    DC2L( 25),    UQX( 25),     UQY( 25),     NCDL( 25),    IAXOPL( 25),
     3    NC61( 25),    IOVRM(25)
      COMMON /BLOCK4/ FOMM(50,6),SMC(50,21),IST(50),     LT(50),
     2    JT1(50),      JT2(50),         NITM(50),     IMM(50),      IMC(50)
      COMMON /BLOCK5/ XLS( 50),     XRS( 50),     FL( 50),      AEL( 50),
     2    SXL( 50),     SYL( 50),     SZL( 50)
      COMMON /BLOCK6/ XLL( 75),     XRL( 75),     QXL( 75),     QYL( 75),
     2    QZL( 75),     IOVRL(75)
      COMMON /BLOCK7/ F( 22),       AE( 22),      SX( 22),      SY( 22),
     2    SZ( 22),      QX( 22),      QY( 22),      QZ( 22),      DX( 22),
     3    DY( 22),      DZ( 22),      ERX( 22),     ERY( 22),     ERZ( 22),
     4    SQX( 22),     SQY( 22),     SQZ( 22),     U1( 22),      V1( 22),
     5    W1( 22),      U2( 22),      V2( 22),      W2( 22),      DS(3,3, 22),
     6    BM1S( 22),    BM2S( 22),    TTS( 22),     AG( 22)
      COMMON /BLOC1/ ZMASS(25),FTMJXX(25),FTMJYY(25),FTMJZZ(25),
     2    FTMJVV(25),TTMJ(25),NFTXX(25),NFTYY(25),NFTZZ(25),NFTVV(25)
      COMMON /BLOC16/ ERXXMJ(5,25),ERYYMJ(5,25),ERZZMJ(5,25),
     2    DXXMJ(5,25),DYYMJ(5,25),DZZMJ(5,25),KOMJ(5,25),KOJ(25)
      COMMON /BALA16/ ERVVMJ(5,25),DVVMJ(5,25)
      COMMON/BLOC24/   AN1(40),AN2(11),NPROB(2)
      COMMON /BLK1/   TOL,     ELEMNT,NJST,   KEEP3C,NCD3C,
     2          KEEP2, KEEP3A,KEEP3B,KEEP4A,KEEP4B,KEEP4C,KEEP5A,
     3          KEEP5B,KEEP5C,KEEP5D,KEEP6, KEEP7, NCD2,  NCD3A,
     4          NCD3B, NCD4A, NCD4B, NCD4C, NCD5A, NCD5B, NCD5C,
     5          NCD5D, NCD6,  NCD7,  IP8,   IP9,   IP10,  ITYPE,
     6          IABAN, IFORE, NM,    NJT,   NST,   NLT,   M,
     7          MP1,   MP2,   ISIT,  LTT,   ITYPEL,IDJ,   NSTL
      COMMON /BLK3/ MNJT,MNST,MNLT,MNM,MNC5,MNC6,MDJT,MNJS,MNE,MNCS,
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     2 MNPCS,MNSS,MNOHM,MNJST,MNJSS
      COMMON /BLK5/ NFSUB,NITF,N1,N2
      COMMON /BLK7/ INLOPT,IFAE,KCFFJ,KOFFQW,KOFFSE
      COMMON / HI / NL, ML, J1
      COMMON/ITC/ ERR1,ERR2,ER1,ER2,DTI,CM,NTI,MM(20),MJ(20),MNITF,
     2            MNITM,NSMJ,NSMM
      COMMON /WARN/ NJNC,NMNC
      COMMON /NIT/ APROB
      COMMON / BR / PCRML, PCRJL, NLR, NLRA
      COMMON /SKT2/     WRX(25,10),  WRY(25,10),  WRZ(25,10),
     2     WRV(25,10),  WRXP(25,10), WRYP(25,10), WRTX(25,10),
     3     WRTY(25,10), WRTZ(25,10), WRTV(25,10), WRTXP(25,10),
     4     WRTYP(25,10)
      COMMON /SKT3/ NCOUNT, NITERF
      COMMON /SKT5/          WRXM (21,10),  WRYM (21,10),  WRZM (21,10),
     2                       WRTXM(21,10),  WRTYM(21,10),  WRTZM(21,10)
      COMMON /SKT6/          NITERM(50), INDEX
      COMMON /SKT11/         MSSINL,        MSSIM1
      COMMON /SKT13/         EPR1S(21,10,3),EPRT1S(21,10,3),
     2                       EPR2S(21,10,3),EPRT2S(21,10,3)
      COMMON /SKT14 / IRV(21,2,10),                      FOMOLD(50,6),
     2                IRVRSE,         ITAPE,             N3
      COMMON /SKT15/    JJ
      COMMON /SKT17/  N4
      COMMON /SKT18/ NCHECK
      COMMON /SKT19/ JCRGCN(25,6), JCUREV(25,6)
      COMMON /SKT20/ MCRGCN(21,3), MCUREV(21,3)
      COMMON /SKT23/ PDELTA
      COMMON /SKT27/ IREAD, IWRITE
      COMMON /SKT30/ MSTIF(25), MLOAD(25), MCDEL(25)
      COMMON /SKT32/ EPBF1 (21,10,3), EPBFT1(21,10,3), SLBF1 (21,10,3),
     2               SLBFT1(21,10,3), EPBF2 (21,10,3), EPBFT2(21,10,3),
     3               SLBF2 (21,10,3), SLBFT2(21,10,3),
     4               EPSMAX(21,2,10), EPSMIN(21,2,10), EPSPRE(21,2,10),
     5               YGROW (21,2,10), YTGROW(21,2,10)
      COMMON /CHAN1/ JTSHR
      COMMON /CHAN2/ SHMC(25)
      COMMON /CHA13/ GAMRS(25,3),GAMRTS(25,3)
      COMMON /CHA19/ JRV(25),JRGION(25)
   11 FORMAT  (  5H1      ,80X , 10HI-----TRIM  )
   12 FORMAT  (20A4)
   13 FORMAT  (A4,A1,A4,A1,A2,17A4)
   14 FORMAT  ( A4, A1, A4, 1X, 2A5,7A8,A4)
   15 FORMAT  (///,     10H       PROB ,//,5X,A4,A1,A4,1X,2A5,7A8,A4)
   16 FORMAT  (///,     17H       PROB (CONTD),/,5X,A4,A1,10X,A5,7A8,A4,///)
   22 FORMAT  ( 1X, 20A4 )
   30 FORMAT  (//,78(1H-),//,
     2 55H  NOTE -  THIS PROBLEM ANALYZED EXCLUDING ALL GEOMETRIC ,/,
     3 55H          NONLINEARITIES - ALL FOLLOW UP PROBLEMS SHOULD,/,
     4 42H          BE ANALYZED WITH SAME PDNO OPTION,/,78(1H-),///)
   35 FORMAT (//,78(1H-),//,
     2 54H NOTE -  THIS PROBLEM ANALYZED EXCLUDING ALL GEOMETRIC     ,/,
     3 57H          NONLINEARITIES - ALL PRIOR PROBLEMS,THIS PROBLEM,/,
     4 56H          DEPENDS ON,SHOULD HAVE BEEN ANALYZED USING SAME,/,
     5 20H          PDNO OPTION,/,78(1H-),//)
   50 FORMAT (//,50H        SOLUTION ABANDONED - THE FOLLOWING CARDS WERE,
     2            10H DISCARDED,//)
   51 FORMAT (//,50H        NO HOLD OPTIONS MAY BE EXERCISED ON FIRST PRO,
     2            15HBLEM OF RUN     )
   98 FORMAT ( /// )
   99 FORMAT (//, 11(1PE11.3),/, 10(1PE11.3),/, 6(1PE11.3) )
  100 FORMAT   ( 16I5,/,3I5,/,5X,15I5)
  101 FORMAT   (4(/),   35H       TABLE 1 - PROGRAM CONTROL DATA,/,
     2          17H       PROBLEM TYPE,I3,///,25X,12HINPUT TABLES,//,
     3      10X,    45H TABLE      HOLD DATA FROM      NUMBER OF CARDS,/,
     4      10X,    45H NUMBER     LAST PROBLEM        ADDED FOR THIS ,/,
     5      10X,    45H           (1 = YES,0 = NO)     PROBLEM       ,//,
     6      10X,5H     2,10X,I3,15X,I3,/,  10X,5H   3A,10X,I3,15X,I3,/,
     6      10X,5H    3B,10X,I3,15X,I3,/,  10X,5H   3C,10X,I3,15X,I3,/,
     6      10X,5H    4A,10X,I3,15X,I3,/,  10X,5H   4B,10X,I3,15X,I3,/,
     6      10X,5H    4C,10X,I3,15X,I3,/,  10X,5H   4D,10X,I3,15X,I3,/,
     6      10X,5H    4E,10X,I3,15X,I3,/,  10X,5H   5A,10X,I3,15X,I3,/,
     6      10X,5H    5B,10X,I3,15X,I3,/,  10X,5H   5C,10X,I3,15X,I3,/,
     6      10X,5H    5D,10X,I3,15X,I3,/,
     6      10X,5H     6,10X,I3,15X,I3,/,  10X,5H    7,10X,I3,15X,I3,/////)
  102 FORMAT (25X,13HOUTPUT TABLES,//,
     2          10X,24H  TABLE     SUPRESS OUTPUT,/,
     3          10X,26H  NUMBER   (1 = YES, 0 = NO),//,
     4      10X,5H    8,10X,I3,/,10X,5H    9,10X,I3,/,10X,5H   10,10X,I3)
  103 FORMAT (25X,13HOUTPUT TABLES,//,
     2          10X,28H  TABLE     TIMESTEP INTERVALS,/,
     3          10X,24H  NUMBER        FOR OUTPUT,//,
     4      10X,5H    8,10X,I3,/,10X,5H    9,10X,I3,/,10X,5H   10,10X,I3)
  109 FORMAT (25X,13HOUTPUT TABLES,//,
     2          10X,  7H  TABLE,/,
     3          10X,  7H NUMBER,//,
     4      10X,5H    8,10X,I3,/,10X,5H    9,10X,I3,/,10X,5H   10,10X,I3)
  151 FORMAT (5X,44HTABLE 8 - JOINT DISPLACEMENTS AND REACTIONS,///,
     4   5X,3HJNT,4X,7HDISP(X),8X,7HDISP(Y),6X,11HROTATION(Z),3X,
     5   8HREACT(X),3X,8HREACT(Y),3X,8HREACT(Z),//)
  152 FORMAT  ( 3X,     I5, 3(1PE15.7), 3(1PE11.3) )
  153 FORMAT  (3X,1H*,I4,3(1PE15.7),3(1PE11.3))
  154 FORMAT  (//,47H      * INDICATES JOINT SUPPORT OFF Q-W CURVE AT,
     2            20H END OF THIS PROBLEM)
  155 FORMAT  (///30H      ***** FRAME ITERATION NO ,I5,6H *****,//,
     2     5X,    43H MEMB MEMB              MEMBER DISPLACEMENTS     ,
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     3      11X,    25H MEMBER EQULIBRIUM ERRORS,/,
     4      5X,     46H  NC  ITER           AXIAL  LATERAL  ROTATIONAL
     5      3X,     32H AXIAL       LATERAL     ROTATIONAL)
  157 FORMAT (52X,3(11H ----------),//,48X,5HTOTAL,3(1PE11.3),
     2      //, 52X,3(11H ----------))
  162 FORMAT (5X,34HTABLE 10 - JOINT EQULIBRIUM ERRORS,///,
     2 4X,5HJOINT,3X,6HERR(X),9X,6HERR(Y),12X,6HERR(Z),/,
     3 12X,5HFORCE,10X,5HFORCE,13X,6HMOMENT,//)
  175 FORMAT (///,5X,I5,    37H JOINTS NCT CONVERGED AT END CF FRAME,
     2              10H ITERATION,I5)
  177 FORMAT (///45H          ALL JOINTS CONVERGED AT END OF ITERATION,I5)
  181 FORMAT (//,15X, 30H SUMMARY OF FRAME ITERATIONS  ,//,5X,
     2 61HJOINT FRAME              JOINT DISPLACEMENTS               JOINT EQUL,
     3 13HIBRIUM ERRORS,/,5X,
     4 61H NO  ITER    DISP(X)      DISP(Y)  ROTATION(Z)    ERR(X)       ER,
     5 15HR(Y)       ERR(Z),//)
  182 FORMAT (5X,2I4,1X,6E11.3)
  183 FORMAT(5X,1H*,I3,I4,1X,6E11.3)
  184 FORMAT (//,48H          * INDICATES JCINT SUPPORT OFF Q-W CURVE FOR,
     2              15H THAT ITERATION)
  185 FORMAT (//, 8H         ***,I5,35H MEMBERS NOT CLOSED AT END OF SPECI,
     2          32HFIED NUMBER OF MEMBER ITERATIONS,/,  11H        DURING,
     3          23H FRAME ITERATION NUMBER,I5, 4H ***)
  195 FORMAT (//,96X,34H-----REVERSAL HAS BEEN SENSED-----)
  196 FORMAT (//,52X,46HIF REVERSAL WAS SENSED EARLIER IN THIS PROBLEM,
     2          /,52X, 45HIGNORE ECULIBRIUM ERRORS PRINTED FOR THE CASE,
     3          /,52X, 32H OF NITF = 1, IN THE ABOVE TABLE)
  200 FORMAT ( 80(1H-),//)
  210 FORMAT (//,78(1H-),//,
     2 49H  NOTE - THIS ANALYSIS INCLUDES SHEAR DEFORMATION,/,
     3 56H         AT THE JOINTS.ALL FCLLCW UP PROBLEMS SHOULD BE ,/,
     4 44H         ANALYZED WITH THE SAME JSYES OPTION,/,78(1H-),//)
  220 FORMAT (//,78(1H-),//,
     2 49H  NOTE - THIS ANALYSIS INCLUDES SHEAR DEFORMATION,/,
     3 53H         AT THE JOINTS.ALL PRIOR PROBLEMS SHOULD HAVE,/,
     4 49H         BEEN ANALYZED WITH THE SAME JSYES OPTION,
     5           /,78(1H-),//)
  231 FORMAT (//,15X, 30H SUMMARY OF FRAME ITERATIONS  ,//,5X,
     2 60H      JOINT FRAME               JOINT DISPLACEMENTS                ,
     3 33H         JCINT EQUILIBRIUM ERRCRS  ,/,
     4 60H      NO  ITER    DISP(X)      DISP(Y)      ROT(Z)       ROT(V)    ,
     5 41H ERR(X)      ERR(Y)       ERR(Z)      ERR(V)  ,//)
  232 FORMAT (5X,2I4,1X,8E11.3)
  233 FORMAT(5X,1H*,I3,I4,1X,8E11.3)
  234 FORMAT (5X,44HTABLE 8 - JOINT DISPLACEMENTS, REACTIONS AND,
     2 29H SHEAR PANEL INTERNAL MCMENTS,///,
     3 57H  JNT      DISP(X)          DISP(Y)          ROT(Z)          RO,
     4 50HT(V)      REACT(X)   REACT(Y)    REACT(Z)   REACT(V),
     5 24H   SHR.MOM(Z) SHR.MOM(V),//)
  235 FORMAT  ( 1X,      I4, 4(1PE15.7), 6(1PE11.3) )
  236 FORMAT (1X,1H*,I3,4(1PE15.7),6(1PE11.3))
  237 FORMAT (65X,4(11H ----------),//,60X,5HTOTAL,4(1PE11.3),
     2      //, 65X,4(11H ----------))
  238 FORMAT (5X,34HTABLE 10 - JCINT ECULIBRIUM ERRORS,///,
     2 4X,5HJOINT,3X,6HERR(X),9X,6HERR(Y),10X,6HERR(Z),9X,6HERR(V),/,
     3 12X,5HFORCE,10X,5HFORCE,11X,6HMOMENT,9X,6HMOMENT,//)
  777 FORMAT (    48H       ***    SOLUTION DID NOT CLOSE - STUDY MONITOR,
     2             10H DATA *** )
COMMENT - SET CONTRCL CONSTANTS
                DATA ITEST1,PRINT
     2           / 4HCEAS, 4HRINT /
                DATA MEMBER /4HMBER/
                DATA PDNO /4HPDNO/, PDN/4H PDN/
                DATA JSYES /5HJSYES/
                DATA SHEAR /5HSHEAR/
                IREAD = 11
                IWRITE= 12
                ITYPEL = 0
                N1 = 2
                N2 = 1
                N3 = 4
                N4 = 3
                KSETPD = 0
                KSETJS=0
COMMENT - READ RUN ID,PRINT PROGRAM ID AND RUN ID
      READ 12, ( AN1(II),II = 1,40)
      PRINT 11
      PRINT 22, ( AN1(II), II=1,40 )
COMMENT - RETURN HERE TO READ NEW PROBLEM
 1010 READ 14, NPRCB, PDEL,JTSHR,(AN2(II),II=1,9)
COMMENT - IF NPROB = CEASE, TERMINATE RUN
          IF ( NPROB(1) .EQ. ITEST1 ) GO TO 9900
                APROB = AN2(9)
COMMENT - INPUT AND ECHO PRINT PRCGRAM CONTROL DATA (TABLE 1)
      READ 100,ITYPE,KEEP2,KEEP3A,KEEP3B,KEEP3C,KEEP4A,KEEP4B,KEEP4C,
     2    KEEP4D,KEEP4E,KEEP5A,KEEP5B,KEEP5C,KEEP5D,KEEP6,KEEP7,IP8,
     3    IP9,IP10,NCD2,NCD3A,NCD3B,NCD3C,NCD4A,NCD4B,NCD4C,NCD4D,NCD4E,
     4    NCD5A,NCD5B,NCD5C,NCD5D,NCD6,NCD7
 1050 PRINT 11
          IF ( ITYPE .EQ. 1 .OR. ITYPE .EQ. 9 ) GO TO 1060
          GO TO 1100
 1060     CONTINUE
          IF ( KSETPD .NE. 0 ) GO TO 1090
                PDELTA = PDEL
                KSETPD = 1
          IF ( PDEL.EQ.PDNO .OR.PDEL.EQ.PDN ) GO TO 1070
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              GO TO 1090
  1070        CONTINUE
COMMENT - PRINT NOTE & WARNING MESSAGE AT THE BEGINNING OF A
COMMENT - FRESH RUN
              IF ( ITYPE .EQ. 9 ) GO TO 1080
        PRINT 30
              GO TO 1090
  1080        CONTINUE
        PRINT 35
  1090        CONTINUE
              IF ( KSETJS .NE. 0 ) GO TC 1100
                  KSETJS = 1
              IF (JTSHR.EQ.JSYES) GO TO 1095
              GO TO 1100
  1095        CONTINUE
COMMENT - PRINT NOTE & WARNING MESSAGE ABOUT THE JOINT SHEAR AT THE
COMMENT - BEGINNING OF A FRESH RUN
              IF ( ITYPE .EQ. 9 ) GO TO 1098
        PRINT 210
              GO TO 1100
  1098        CONTINUE
        PRINT 220
  1100        CONTINUE
        PRINT 22, ( AN1(II), II=1,40 )
        PRINT 15,NPROB, PDEL,JTSHR,(AN2(II),II=1,9)
        PRINT 101, ITYPE,KEEP2,NCD2,KEEP3A,NCD3A,KEEP3B,NCD3B,KEEP3C,
     2        NCD3C,KEEP4A,NCD4A,KEEP4B,NCD4B,KEEP4C,NCD4C,KEEP4D,NCD4D,
     3        KEEP4E,NCD4E,KEEP5A,NCD5A,KEEP5B,NCD5B,KEEP5C,NCD5C,
     4        KEEP5D,NCD5D,KEEP6,NCD6,KEEP7,NCD7
              IF ( ITYPE .GT. 2 ) GO TO 1120
        PRINT 102, IP8, IP9, IP10
              GO TO 1150
  1120        IF ( ITYPE .GT. 4 ) GO TO 1140
        PRINT 103, IP8, IP9, IP10
              GO TO 1150
  1140  PRINT 109, IP8, IP9, IP10
  1150        CONTINUE
COMMENT - CHECK FOR KEEP OPTION ON FIRST PROBLEM OF RUN
                  KEKE = KEEP2+KEEP3A+KEEP3B+KEEP3C+KEEP4A+KEEP4B+KEEP4C+
     2            KEEP4D+KEEP4E+KEEP5A+KEEP5B+KEEP5C+KEEP5D+KEEP6+KEEP7
              IF ( ITYPEL .EQ. 0 .AND. KEKE .NE. 0 ) GO TO 1200
              GO TO 1300
  1200  PRINT 51
COMMENT - ABORT PROBLEM,SEARCH FOR INDEPENDENT PROBLEM
              GO TO 9805
  1300        CONTINUE
COMMENT - IABAN = 1 INDICATES FATAL ERROR FOUND IN SUBROUTINE
COMMENT - PROBLEM ABANDONED IN SEARCH OF AN INDEPENDENT PROBLEM
                  IABAN = 0
                  NLR = 0
COMMENT - MAIN PROGRAM STARTS HERE
        PRINT 11
        PRINT 16,NPROB,(AN2(II),II=1,9)
COMMENT - SUBROUTINE JTCORD INPUTS JOINT GEOMETRY DATA (TABLE 2)
COMMENT - CHECKS FOR BAD DATA, COMPUTES JOINT COORDINATES,ECHO PRINTS
COMMENT - DATA AND PRINTS COMPUTED JOINT COORDINATES
        CALL      JTCORD
              IF ( IABAN .EQ. 1 ) GO TO 9805
                  TEMP  = KEEP3A + KEEP3B + KEEP3C
                  TEMPP =  NCD3A +  NCD3B +  NCD3C
              IF ( TEMP .NE. 0 .AND. TEMPP .EQ. 0 ) GO TO 1410
              GO TO 1420
  1410  PRINT 200
              GO TO 1430
  1420        CONTINUE
        PRINT 11
        PRINT 16,NPROB,(AN2(II),II=1,9)
  1430        CONTINUE
COMMENT - SUBROUTINE MEMLOC INPUTS LOCATION OF MEMBER STIFFNESS AND LOAD
COMMENT - TYPES IN FRAME, AND JOINT DATA AND JOINT SHEAR STRESS-STRAIN
COMMENT - CURVES FOR ANALYSIS THAT INCLUDES JOINT SHEAR DEFORMATION
COMMENT - EFFECTS (TABLE 3). ALSO COMPUTES MEMBER NUMBERS, LENGTHS, ETC.
        CALL      MEMLOC
              IF ( IABAN .EQ. 1 ) GO TO 9805
                  TEMP  = KEEP4A + KEEP4B + KEEP4C + KEEP4D + KEEP4E
                  TEMPP =  NCD4A +  NCD4B +  NCD4C +  NCD4D +  NCD4E
              IF ( TEMP .NE. 0 .AND. TEMPP .EQ. 0 ) GO TO 1440
              GO TO 1450
  1440  PRINT 200
              GO TO 1460
  1450        CONTINUE
        PRINT 11
        PRINT 16,NPROB,(AN2(II),II=1,9)
  1460        CONTINUE
COMMENT - SUBROUTINE JNTDAT INPUTS JOINT LOADS AND RESTRAINTS
COMMENT - (TABLE 4),CHECKS FOR BAD DATA,ACCUMULATES JOINT LOADS AND
COMMENT - RESTRAINTS,ECHO PRINTS DATA AND PRINTS ACCUMULATED DATA
COMMENT - EQUILIBRIUM ERRORS ARE SET EQUAL TO NET JOINT LOADS
        CALL      JNTDAT
              IF ( IABAN .EQ. 1 ) GO TO 9805
              IF ( NLR .NE. 0 ) GO TO 1500
                  TEMP  = KEEP5A + KEEP5B + KEEP5C + KEEP5D
                  TEMPP =  NCD5A +  NCD5B +  NCD5C +  NCD5D
              IF ( TEMP .NE. 0 .AND. TEMPP .EQ. 0 ) GO TO 1470
              GO TO 1480
  1470  PRINT 200
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      GO TO 1490
1480  CONTINUE
    PRINT 11
    PRINT 16,NPROB, (AN2(II),II=1,9)
1490  CONTINUE
COMMENT - SUBROUTINE RDMST  INPUTS MEMBER STIFFNESS DATA (TABLE 5),
COMMENT - CHECKS FOR BAD DATA AND ECHO PRINTS DATA
    CALL      RDMST
       IF ( IABAN .EQ. 1 ) GO TO 9805
       IF ( KEEP6 .EQ. 1 .AND. NCD6 .EQ. 0 ) GO TO 1500
       GO TO 1510
1500 PRINT 200
       GO TO 1520
1510   CONTINUE
    PRINT 11
    PRINT 16,NPROB,(AN2(II),II=1,9)
1520   CONTINUE
COMMENT - SUBROUTINE RDMLD  INPUTS MEMBER LOAD DATA (TABLE 6) CHECKS
COMMENT - FOR BAD DATA, CONVERTS LOADS AND DISTANCES TO MEMBER
COMMENT - COORDINATES AND ECHO PRINTS DATA
    CALL      RDMLD
       IF ( IABAN .EQ. 1 ) GO TO 9805
       IF ( NLR .NE. 0 ) GO TO 1560
       IF (KEEP7.EQ.1 .AND. NCD7.EQ.0 .AND. ITYPE.EQ.9 ) GO TO 1530
       GO TO 1540
1530 PRINT 200
       GO TO 1550
1540   CONTINUE
    PRINT 11
    PRINT 16,NPROB,(AN2(II),II=1,9)
1550   CONTINUE
COMMENT - SUBROUTINE ITCONT INPUTS ITERATION CONTROL DATA, CHECKS FOR
COMMENT - BAD DATA AND ECHO PRINTS DATA
    CALL      ITCONT
       IF ( IABAN .EQ. 1 ) GO TO 9805
       IF ( ITYPE .NE. 9 ) GO TO 1560
          ITYPEL = ITYPE
       GO TO 1010
1560   CONTINUE
       IF ( ITYPEL .NE. 9 .AND. NLR .EQ. 0 ) GO TO 2000
       IF ( ITYPE .EQ. 1 ) GO TO 2000
       IF ( ITYPE .GE. 3 ) GO TO 2100
    REWIND 13
    READ (13) IREAD
       IF ( IREAD .EQ. 11 ) IWRITE = 12
       IF ( IREAD .EQ. 12 ) IWRITE = 11
    REWIND IREAD
       IF (JTSHR .EQ. JSYES) GO TO 1575
    READ ( IREAD ) ( DXX(I), DYY(I), DZZ(I), I=1,NJT )
       DO 1565 I = 1,NJT
          NTEMP = NSXX(I) + NSYY(I) + NSZZ(I) + NSXP(I) + NSYP(I)
       IF ( NTEMP .EQ. 0 ) GO TO 1565
    READ (IREAD )   (WRX(I,J),WRTX(I,J),WRY(I,J),WRTY(I,J),WRZ(I,J),
   2              WRTZ(I,J),WRXP(I,J), WRTXP(I,J),WRYP(I,J),WRTYP(I,J),
   3              J = 1,10 )
1565   CONTINUE
COMMENT - INITIALISE REVERSAL INDICATORS FOR JOINT CURVES
       DO 1570 I = 1,MNJT
       DO 1570 N = 1,5
          JCUREV(I,N) = 0
1570   CONTINUE
       GO TO 1590
1575   CONTINUE
    READ (IREAD)  (DXX(I),DYY(I),DZZ(I),DVV(I),I=1,NJT)
    READ (IREAD)  ((GAMRS(I,J),GAMRTS(I,J),J=1,3),I=1,NJT)
COMMENT - INITIALISE REVERSAL INDICATORS FOR JOINT SHEAR STRESS-STRAIN
COMMENT - CURVES.
       DO 1586 I = 1,NJT
          JRV(I) = 0
1586   CONTINUE
       DO 1587 I = 1,NJT
          NTEMP = NSXX(I)+NSYY(I)+NSZZ(I)+NSVV(I)+NSXP(I)+NSYP(I)
       IF ( NTEMP .EQ. 0 ) GO TO 1587
    READ (IREAD )   (WRX(I,J),WRTX(I,J),WRY(I,J),WRTY(I,J),WRZ(I,J),
   2              WRTZ(I,J),WRV(I,J),WRTV(I,J),WRXP(I,J),WRTXP(I,J),
   3              WRYP(I,J),WRTYP(I,J), J = 1,10 )
1587   CONTINUE
COMMENT - INITIALISE REVERSAL INDICATORS FOR JOINT CURVES
       DO 1588 I = 1,MNJT
       DO 1588 N = 1,6
          JCUREV(I,N) = 0
1588   CONTINUE
1590   CONTINUE
    REWIND N2
    REWIND N4
       DO 1700 JJ = 1,NM
          ISTT = IST(JJ)
       IF ( ISTT .EQ. 0 ) GO TO 1700
          MODELT = MODEL(ISTT)
          M = MSTIF (ISTT)
         MP1= M+1
         MP2= M+2
    READ ( IREAD ) ( DX(I), DY(I), DZ(I), I=1,MP2 )
    WRITE (N2)  ( DX(I), DY(I), DZ(I), I = 1,MP2 )
       IF ( INLOP(ISTT) .EQ. 0 ) GO TO 1700
          NREAD = NSXL(ISTT)+NSYL(ISTT)+NSZL(ISTT)
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      IF ( NREAD .EQ. 0 ) GO TO 1600
      READ (IREAD ) ((WRXM(I,J),WRTXM(I,J),WRYM(I,J),WRTYM(I,J),
     2              WRZM(I,J), WRTZM(I,J), J = 1,10), I = 2,MP1 )
      WRITE (N2) (( WRXM(I,J), WRTXM(I,J), WRYM(I,J), WRTYM(I,J),
     2              WRZM(I,J), WRTZM(I,J), J = 1,10), I = 2,MP1 )
 1600     CONTINUE
          IF ( MODELT .LE. -1 ) GO TO 1605
              ELEMNT = ELEMN(ISTT)
          IF (ELEMNT .EQ. SHEAR) GO TO 1602
              NHINGE = 2
      READ (IREAD ) (((EPR1S(I,J,K),EPRT1S(I,J,K),EPR2S(I,J,K),
     2              EPRT2S(I,J,K),K = 1,MSSIM1), J=1,MNPCS), I=2,MP1 )
      WRITE (N2) ((( EPR1S(I,J,K), EPRT1S(I,J,K), EPR2S(I,J,K),
     2              EPRT2S(I,J,K),K = 1,MSSIM1), J=1,MNPCS), I=2,MP1 )
          IF ( MODELT .EQ.  0 ) GO TO 1605
      READ  (IREAD ) (((EPBF1 (I,J,K), EPBFT1(I,J,K), SLBF1 (I,J,K),
     2                  SLBFT1(I,J,K), EPBF2 (I,J,K), EPBFT2(I,J,K),
     3                  SLBF2 (I,J,K), SLBFT2(I,J,K), K=1,MSSIM1 ),
     4                  J = 1,MNPCS ), I = 2,MP1 )
      WRITE (N2    ) (((EPBF1 (I,J,K), EPBFT1(I,J,K), SLBF1 (I,J,K),
     2                  SLBFT1(I,J,K), EPBF2 (I,J,K), EPBFT2(I,J,K),
     3                  SLBF2 (I,J,K), SLBFT2(I,J,K), K=1,MSSIM1 ),
     4                  J = 1,MNPCS ), I = 2,MP1 )
          GO TO 1603
 1602         NHINGE=1
      READ (IREAD ) (((EPR1S(I,J,K),EPRT1S(I,J,K),
     2              K = 1,MSSIM1), J=1,MNPCS), I=2,MP1 )
      WRITE (N2) ((( EPR1S(I,J,K), EPRT1S(I,J,K),
     2              K = 1,MSSIM1), J=1,MNPCS), I=2,MP1 )
          IF ( MODELT .EQ.  0 ) GO TO 1605
      READ  (IREAD ) (((EPBF1 (I,J,K), EPBFT1(I,J,K), SLBF1 (I,J,K),
     2                  SLBFT1(I,J,K), K=1,MSSIM1 ),J=1,MNPCS),I=2,MP1)
      WRITE (N2    ) (((EPBF1 (I,J,K), EPBFT1(I,J,K), SLBF1 (I,J,K),
     2                  SLBFT1(I,J,K), K=1,MSSIM1 ),J=1,MNPCS),I=2,MP1)
 1603     CONTINUE
      READ  (IREAD ) (((EPSMAX(I,L,J), EPSMIN(I,L,J), EPSPRE(I,L,J),
     2                  J = 1,MNPCS ), L = 1,NHINGE ), I = 2,MP1 )
      WRITE (N2    ) (((EPSMAX(I,L,J), EPSMIN(I,L,J), EPSPRE(I,L,J),
     2                  J = 1,MNPCS ), L = 1,NHINGE ), I = 2,MP1 )
          IF ( MODELT .NE. 2 ) GO TO 1605
      READ  (IREAD ) (((YGROW (I,L,J), YTGROW(I,L,J), J = 1,MNPCS ),
     2                  L = 1,NHINGE ), I = 2,MP1 )
      WRITE (N2    ) (((YGROW (I,L,J), YTGROW(I,L,J), J = 1,MNPCS ),
     2                  L = 1,NHINGE ), I = 2,MP1 )
 1605     CONTINUE
          IF ( NREAD .EQ. 0 ) GO TO 1620
          DO 1610 I = 2,MP1
          DO 1610 N = 1,3
              MCUREV(I,N) = 0
 1610     CONTINUE
      WRITE (N4) ((MCUREV(I,N), N=1,3), I=2,MP1 )
 1620     CONTINUE
          IF ( MODELT .LE. -1 ) GO TO 1700
          DO 1650 I = 2,MP1
          DO 1650 L = 1,NHINGE
          DO 1650 J = 1,MNPCS
              IRV(I,L,J) = 0
 1650     CONTINUE
      WRITE (N4) ((( IRV(I,L,J), J = 1,MNPCS),L=1,NHINGE),I = 2,MP1 )
 1700     CONTINUE
      READ ( IREAD ) (( FCMM(I,J), I=1,NM), J=1,6 )
 2000     CONTINUE
          IF (ITYPE .LE. 2) GO TO 5000
 2100     CONTINUE
          IF (JTSUR .EQ. JSYES) GO TO 2200
      CALL DYNA ( RM, RO, W, SL, I1, I3, I4, L6, DELWJT )
      GO TO 1010
 2200     CONTINUE
      CALL        DYNAJS ( RM, RO, W, SL, I1, I3, I4, L6, DELWJT )
          GO TO 1010
 5000     CONTINUE
              ITYPEL = ITYPE
              NITF = 0
              NITERF = 1
COMMENT - IRVRSE = 1 REVERSAL SENSED
COMMENT -        = 0 NOT      SENSED
              IRVRSE = 0
 5100     CONTINUE
          IF ( IRVRSE .EQ. 0 ) GO TO 5105
          IF ( APROB .EQ. PRINT .OR. APROB .EQ. MEMBER ) GO TO 5103
          GO TO 5105
 5103     CONTINUE
      PRINT 195
 5105     CONTINUE
              IFAE = 1
              INDEX = 0
COMMENT - ITAPE = 1 TAPES N1 & N2 ARE SWITCHED AS USUAL
COMMENT -       = 0 NOT SWITCHED
              ITAPE = 1
          IF ( IRVRSE .NE.0 ) ITAPE = 0
          IF ( ITAPE .EQ. 0 ) GO TO 5200
              NT = N2
              N2 = N1
              N1 = NT
 5200     CONTINUE
              NT = N4
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                N4 = N3
                N3 = NT
                NITF = NITF + 1
                NCHECK = 0
      REWIND  N1
      REWIND N2
      REWIND N3
      REWIND N4
COMMENT - FORM MEMBER STIFFNESS MATRICES AND MEMBER FIXED-END-FORCE
COMMENT - MATRICES
          DO 5800  JJ = 1,NM
                ISTT = IST(JJ)
                LTT = LT(JJ)
COMMENT - SKIP FOR NULL MEMBER
          IF (ISTT .EQ. 0) GO TO 5750
COMMENT - SUBROUTINE FORMST CALCULATES MEMBER (6 X 6) STIFFNESS MATRIX
COMMENT - AND TAKING ADVANTAGE OF SYMETRY STORES IN COMPACT VECTOR
COMMENT - SMMT(I = 1, 21)
 5500 CALL        FORMST ( RM, RC, W, SL, SMMT, L1, L3, L4, L6, JJ )
          DO 5510  I = 1,21
 5510           SMC( JJ ,I) = SMMT(I)
 5700     CONTINUE
          IF ( IRVRSE .NE. 0 ) GO TO 5705
          IF (NITF .GT. 1) GO TO 5750
COMMENT - SUBROUTINE FORMLD CALCULATES MEMBER INCREMENTAL FIXED-END-
COMMENT - FORCE MATRIX ON FIRST ITERATION OF EACH PROBLEM
COMMENT - IF REVERSAL HAS OCCURRED, THEN FORMLD IS ONCE AGAIN ACCESSED
 5705     CONTINUE
      CALL        FORMLD ( RM, RO, W, SL, FOMT, L1, L3, L4, L6, JJ)
          DO 5710  I = 1,6
 5710           FOMM(JJ,I) = FOMT(I)
          GO TO 5800
COMMENT - SET FIXED END-FORCE-MATRIX TO NULL MATRIX FOR NULL LOADING
 5750     DO 5780  I = 1,6
 5780           FOMM(JJ,I) = 0.0
 5800     CONTINUE
      REWIND  N1
      REWIND N3
COMMENT - DUMP OF STIFFNESS MATRIX AND LOAD VECTOR,TO ACTIVATE,SET LAST
COMMENT - FIVE COLUMNS IN PROBLEM NUMBER CARD EQUAL TO PRINT
          IF (APROB .NE. PRINT) GO TO 77777
          DO 5900  JJ = 1,NM
                ISTT = IST(JJ)
                LTT = LT(JJ)
          IF (ISTT .EQ. 0) GO TO 5900
      PRINT 99, ( SMC(JJ,I), I=1,21), ( FOMM(JJ,I), I=1,6 )
 5900     CONTINUE
      PRINT 98
77777     CONTINUE
          IF (JTSHR .EQ. JSYES) GO TO 16000
COMMENT - START SOLUTION OF FRAME JOINT EQUILIBRIUM EQUATIONS
COMMENT - SET CONTROL CONSTANTS FOR FRAME SOLUTION
                IHB = 3*IDJ + 2
                NL = 3*NJT
                ML = 1
                NFSUB = 21
          IF ( ITYPE .EQ. 2 ) GO TO 6300
          IF (NITF .GT. 1) GO TO 6300
COMMENT - ZERO JOINT DISPLACEMENT UNLESS HOLDING FROM A PREVIOUS PROBLEM
COMMENT - OR A PREVIOUS ITERATION
          DO 6250 I = 1,NJT
                DXX(I) = 0.0
                DYY(I) = 0.0
 6250           DZZ(I) = 0.0
 6300     CONTINUE
          IF ( ITYPE .EQ. 1 .AND. NITF .EQ. 1 ) GO TO 6320
          IF ( IRVRSE .EQ. 0 ) GO TO 6320
COMMENT - DECREMENT JOINT DISPLACEMENTS
                J = 0
          DO 6310 I = 1 , NJT
                J = J + 1
                DXX(I) = DXX(I) - DELWJT(J)
                J = J + 1
                DYY(I) = DYY(I) - DELWJT(J)
                J = J + 1
                DZZ(I) = DZZ(I) - DELWJT(J)
 6310     CONTINUE
 6320     CONTINUE
                INDEX = 0
COMMENT - CALL GRIP2A FOR SOLUTION OF FRAME JOINT EQUILIBRIUM EQUATIONS
COMMENT - GRIP2A SOLVES BOTH FRAME JOINT EQUILIBRIUM EQUATIONS AND
COMMENT - MEMBER EQUILIBRIUM EQUATIONS - GRIP2A CALLS FSUB1 WHICH CALLS
COMMENT - FSUB21 TO SET UP FRAME EQUATIONS OR FSUB22 TO SET UP MEMBER
COMMENT - EQUATIONS
      CALL        GRIP2A ( RM, RO, W, SL, L3, L4, L6, IHB )
          IF (IHB .LT. 10000) GO TO 6350
          GO TO 9800
COMMENT - ADD ON INCREMENTS OF JOINT DISPLACEMENTS
 6350           J = 0
          DO 6500  I = 1, NJT
                J = J + 1
                DXX(I) = DXX(I) + W(J)
                DELWJT ( J ) = W ( J )
                J = J + 1
                DYY(I) = DYY(I) + W(J)
                DELWJT ( J ) = W ( J )
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            J = J + 1
            DZZ(I) = DZZ(I) + W(J)
            DELWJT ( J ) = W ( J )
 6500    CONTINUE
            NITERF = NITERF + 1
            NCHECK = 0
            INDEX = 0
         IF (NITERF .NE. 2) GO TO 6510
            NCHECK = 1
            INDEX = 1
 6510    CONTINUE
            IRVRSE = 0
            NMJ = 0
            KOFFJ = 0
COMMENT - SOLVE FOR JOINT REACTIONS
         DO 6600  I = 1,NJT
COMMENT - SUBROUTINE INELST CALCULATES THE RESISTIVE SPRING FORCE AND
COMMENT - THE SPRING STIFFNESS FOR THE JOINT SPRINGS FOLLOWING
COMMENT - NONLINEAR LOADING , INELASTIC UNLOADING PATH
      CALL        INELST (I,SJX,SJY,SJZ,SJV,SJXY,QJX,QJY,QJZ,QJV)
COMMENT - SKIP EQUILIBRIUM CALCULATIONS IF REVERSAL HAS BEEN SENSED.
         IF ( IRVRSE .NE. 0 ) GO TO 6600
            RXX(I) = - SXX(I)*DXX(I) + QJX
            RYY(I) = - SYY(I)*DYY(I) + QJY
            RZZ(I) = - SZZ(I)*DZZ(I) + QJZ
            KOJ(I) = KOFFJ
         IF (IMJ(I) .EQ. 0) GO TO 6600
            NMJ = NMJ + 1
            KOMJ(NMJ,NITF) = KOFFJ
 6600    CONTINUE
         IF ( IRVRSE .NE. 0 ) GO TO 7300
COMMENT - COMPUTE FOR EACH JOINT - THE SUM OF APPLIED JOINT LOAD
COMMENT - AND THE REACTION - WHEN THE APPROPRIATE MEMBER END FORCES ARE
COMMENT - SUBTRACTED FROM THIS SUM THE RESULT IS THE JOINT EQUILIBRIUM
COMMENT - ERRORS
      DO 7250  I = 1,NJT
            ERXX(I) = QXX(I) + RXX(I)
         IF(DABS(QXX(I)) .GE. 1.0E+15) ERXX(I) = 0.0
            ERYY(I) = QYY(I) + RYY(I)
         IF(DABS(QYY(I)) .GE. 1.0E+15) ERYY(I) = 0.0
            ERZZ(I) = QZZ(I) + RZZ(I)
         IF(DABS(QZZ(I)) .GE. 1.0E+15) ERZZ(I) = 0.0
 7250    CONTINUE
         IF ( APROB .EQ. PRINT .OR. APROB .EQ. MEMBER ) GO TO 7260
         GO TO 7300
 7260    CONTINUE
      PRINT 155, NITF
 7300    CONTINUE
COMMENT - START NONLINEAR MEMBER SOLUTION
            IFAE = 0
            NMNC = 0
         DO 7500  JJ = 1,NM
            IMC(JJ) = 0
            NITM(JJ) = 0
COMMENT - CALL SUBROUTINE MEMSOL FOR ITERATIVE SOLUTION OF MEMBER TO
COMMENT - FIND MEMBER-END-FORCES FOR JOINT EQULIBRIUM CHECK IN FRAME
COMMENT - SOLUTION
      CALL        MEMSOL (     EM,RC,W,SL,L1,L3,L4,L6)
         IF (IMC(JJ) .EQ. 1)  NMNC = NMNC + 1
 7500    CONTINUE
         IF ( IRVRSE .EQ. 0 ) GO TO 7600
COMMENT - SAVE JOINT DISPLACEMENTS (ONLY) FROM THIS FIRST ITERATION
COMMENT - FOR MONITOR JOINTS
            NMJ = 0
         DO 7650 I = 1,NJT
         IF ( IMJ(I) .EQ. 0 ) GO TO 7650
            NMJ = NMJ + 1
            DXXMJ(NMJ,1) = DXX(I)
            DYYMJ(NMJ,1) = DYY(I)
            DZZMJ(NMJ,1) = DZZ(I)
 7650    CONTINUE
COMMENT - RETURN FOR THE ADDITIONAL FRAME ITERATION(REVERSAL CASE)
         GO TO 5100
 7600    CONTINUE
            NMJ = 0
COMMENT - SAVE JOINT DISPLACEMENTS AND EQUILIBRIUM ERRORS FROM THIS
COMMENT - ITERATION FOR MONITOR JOINTS
         DO 7700 I = 1,NJT
         IF (IMJ(I) .EQ. 0) GO TO 7700
            NMJ = NMJ + 1
            ERXXMJ(NMJ,NITF) = ERXX(I)
            ERYYMJ(NMJ,NITF) = ERYY(I)
            ERZZMJ(NMJ,NITF) = ERZZ(I)
            DXXMJ(NMJ,NITF) = DXX(I)
            DYYMJ(NMJ,NITF) = DYY(I)
            DZZMJ(NMJ,NITF) = DZZ(I)
 7700    CONTINUE
 8000 CONTINUE
COMMENT - COMPUTE NUMBER OF JOINTS NOT CLOSED --- SKIP CHECKS CORRESPOND
COMMENT - ING TO SPECIFIED DISPLACEMENTS
            NJNC = 0
         DO 8700  I = 1,NJT
         IF(DABS(ERXX(I)) .GT. ERR1 .AND.DABS(QXX(I)) .LT. 1.0E+15)
     2            GO TO 8600
         IF(DABS(ERYY(I)) .GT. ERR1 .AND.DABS(QYY(I)) .LT. 1.0E+15)
     2            GO TO 8600
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          IF(DABS(ERZZ(I)) .GT. ERR2 .AND.DABS(QZZ(I)) .LT. 1.0E+15)
     2                GO TO 8600
          GO TO 8700
 8600            NJNC = NJNC + 1
 8700     CONTINUE
          IF (NJNC .EQ. 0) GO TO 8900
      PRINT 175, NJNC,NITF
          IF ( NITF .EQ. MNITF) GC TO 8950
          IF (NMNC .GT. 0)  GC TC 8950
COMMENT - RETURN FOR NEXT FRAME ITERATION
          GO TO 5100
 8900     CONTINUE
          IF ( APROB .EQ. PRINT .OR. APROB .EQ. MEMBER ) GO TO 8920
          GO TO 8950
 8920     CONTINUE
      PRINT 177, NITF
 8950     CONTINUE
          IF (NMNC .GT. 0)  PRINT 185, NMNC, NITF
COMMENT - PRINT SUMMARY CF FRAME ITTERATIONS
      PRINT  181
               NMJ = 0
               KASTER = 0
          DO 8960  I = 1,NJT
          IF (IMJ(I) .EQ. 0) GO TO 8960
               NMJ = NMJ + 1
          DO 8955  J = 1,NITF
          IF (KOMJ(NMJ,J) .EQ. 1) GO TO 8952
      PRINT 182, I,J,DXXMJ(NMJ,J),DYYMJ(NMJ,J),DZZMJ(NMJ,J),
     2    ERXXMJ(NMJ,J), ERYYMJ(NMJ,J), ERZZMJ(NMJ,J)
          GO TO 8955
 8952          KASTER = 1
      PRINT 183, I,J,DXXMJ(NMJ,J),DYYMJ(NMJ,J),DZZMJ(NMJ,J),
     2    ERXXMJ(NMJ,J), ERYYMJ(NMJ,J), ERZZMJ(NMJ,J)
 8955     CONTINUE
 8960     CONTINUE
          IF (KASTER .EQ. 1) PRINT 184
          IF ( APROB .EQ. PRINT .OR. APROB .EQ. MEMBER ) GO TO 8961
          GO TO 88961
 8961     CONTINUE
          IF ( ITYPE .EQ. 1 ) GO TO 88961
      PRINT 196
88961     CONTINUE
COMMENT - PRINT TABLE 8 IF REQUESTED
          IF (IP8 .EQ. 1) GO TO 8970
      PRINT 11
      PRINT 16,NPROB,(AN2(II),II=1,9)
          IF (NJNC .GT. 0 .OR. NMNC .GT. 0)  PRINT 777
      PRINT 151
               KASTER = 0
               TEMPXX = 0.0
               TEMPYY = 0.0
               TEMPZZ = 0.0
          DO 8966 I = 1,NJT
          IF (KOJ(I) .EQ. 1) GO TC 8962
      PRINT 152, I, DXX(I), DYY(I), DZZ(I), RXX(I), RYY(I), RZZ(I)
          GO TO 8963
 8962          KASTER = 1
      PRINT 153, I, DXX(I), DYY(I), DZZ(I), RXX(I), RYY(I), RZZ(I)
 8963     CONTINUE
          IF ( DABS(QXX(I)).GE. 1.0D+15 ) GO TO 8964
               TEMPXX = TEMPXX + RXX(I)
 8964     CONTINUE
          IF ( DABS(QYY(I)).GE. 1.0D+15 ) GO TO 8965
               TEMPYY = TEMPYY + RYY(I)
 8965     CONTINUE
          IF ( DABS(QZZ(I)).GE. 1.0D+15 ) GO TO 8966
               TEMPZZ = TEMPZZ + RZZ(I)
 8966     CONTINUE
      PRINT 157, TEMPXX, TEMPYY, TEMPZZ
          IF (KASTER .EQ. 1) PRINT 154
 8970     CONTINUE
COMMENT - PRINT TABLE 9 IF REQUESTED
COMMENT - EVEN WHEN NCT REQUESTED, SUBRCUTINE  PRINT9 MUST STILL BE
COMMENT - ACCESSED (TO TAKE CARE CF TYPE 9 PROBLEM ), BUT DETAILED
COMMENT - PRINTING CF MEMBER RESULTS WILL BE AVOIDED
      REWIND N1
      REWIND N2
               NT = N1
               N1 = N2
               N2 = NT
COMMENT - SUBROUTINE PRINT9 OUTPUTS MEMBER RESULTS
      CALL          PRINT9 (AN2,NPROB,EM,FO,W,SL,L1,L3,L4,L6)
 8980     CONTINUE
COMMENT - PRINT TABLE 10 (JOINT ECUILIBRIUM ERRORS)IF REQUESTED
          IF (IP10 .EQ. 1) GO TO 8990
      PRINT 11
      PRINT 16,NPROB,(AN2(II),II=1,9)
          IF (NJNC .GT. 0 .OR. NMNC .GT. 0)  PRINT 777
      PRINT 162
      DO 8985  I = 1,NJT
 8985 PRINT 152, I, ERXX(I), ERYY(I), ERZZ(I)
          GO TO 8990
16000     CCNTINUE
COMMENT - START SOLUTION CF FRAME JOINT EQUILIBRIUM EQUATIONS
COMMENT - FOR JOINT SHEAR OPTION
COMMENT - SET CONTRCL CONSTANTS FCR FRAME SCLUTION
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              IHB = 4*IDJ + 3
COMMENT - CALCULATE THE NUMBER OF DEGREES OF FREEDOM
              NL = 3*NJT
        DO 16100 I=1,NJT
        IF (JST(I) .NE. 0) NL=NL+1
16100 CONTINUE
              ML = 1
              NFSUB = 23
        IF ( ITYPE .EQ. 2 ) GC TO 16300
        IF (NITF .GT. 1) GO TO 16300
COMMENT - ZERO JOINT DISPLACEMENT UNLESS HOLDING FROM A PREVICUS PROBLEM
COMMENT - OR A PREVIOUS ITERATION
        DO 16250 I = 1,NJT
              DXX(I) = 0.0
              DYY(I) = 0.0
              DZZ(I) = 0.0
16250         DVV(I) = 0.0
16300   CONTINUE
        IF ( ITYPE .EQ. 1 .AND. NITF .EQ. 1 ) GO TO 16320
        IF ( IRVRSE .EQ. 0 ) GO TO 16320
COMMENT - DECREMENT JOINT DISPLACEMENTS
              J = 0
        DO 16310 I = 1 , NJT
              J = J + 1
              DXX(I) = DXX(I) - DELWJT(J)
              J = J + 1
              DYY(I) = DYY(I) - DELWJT(J)
              J = J + 1
              DZZ(I) = DZZ(I) - DELWJT(J)
        IF (JST(I) .NE. 0) GO TC 16305
              DVV(I) = 0.0
        GO TO 16310
16305         J = J + 1
              DVV(I) = DVV(I) - DELWJT(J)
16310   CONTINUE
16320   CONTINUE
              INDEX = 0
COMMENT - CALL GRIP2A FOR SOLUTICN OF FRAME JCINT EQUILIBRIUM EQUATICNS
COMMENT - GRIP2A SOLVES BOTH FRAME JOINT EQUILIBRIUM ECUATICNS AND
COMMENT - MEMBER EQUILIBRIUM EQUATIONS - GRIP2A CALLS FSUB1 WHICH CALLS
COMMENT - FSUB23 TO SET UP FRAME EQUATICNS.
     CALL     GRIP2A ( RM, RO, W, SL, L3, L4, L6, IHB )
        IF (IHB .LT. 10000) GO TO 16350
        GO TO 9800
COMMENT - ADD ON INCREMENTS OF JOINT DISPLACEMENTS
16350         J = 0
        DO 16500 I = 1, NJT
              J = J + 1

              DXX(I) = DXX(I) + W(J)
              DELWJT ( J ) = W ( J )
              J = J + 1
              DYY(I) = DYY(I) + W(J)
              DELWJT ( J ) = W ( J )
              J = J + 1
              DZZ(I) = DZZ(I) + W(J)
              DELWJT ( J ) = W ( J )
        IF (JST(I) .NE. 0) GO TC 16360
              DVV(I) = 0.0
        GO TO 16500
16360         J = J + 1
              DVV(I) = DVV(I) + W(J)
              DELWJT ( J ) = W ( J )
16500   CONTINUE
              NITERF = NITERF + 1
              NCHECK = 0
              INDEX = 0
        IF (NITERF .NE. 2) GO TC 16510
              NCHECK = 1
              INDEX = 1
16510   CONTINUE
              IRVRSE = 0
              NMJ = 0
              KOFFJ = 0
COMMENT - SOLVE FOR JOINT REACTICNS
        DO 16600 I = 1,NJT
COMMENT - SUBROUTINE INELST CALCULATES THE RESISTIVE SPRING FORCE AND
COMMENT - THE SPRING STIFFNESS FOR THE JOINT SPRINGS FOLLOWING
COMMENT - NONLINEAR LOADING , INELASTIC UNLCADING PATH
     CALL     INELST (I,SJX,SJY,SJZ,SJV,SJXY,QJX,QJY,QJZ,QJV)
COMMENT - SKIP EQUILIBRIUM CALCULATICNS IF REVERSAL HAS BEEN SENSED.
        IF ( IRVRSE .NE. 0 ) GO TO 16600
              RXX(I) = - SXX(I)*DXX(I) + QJX
              RYY(I) = - SYY(I)*DYY(I) + QJY
              RZZ(I) = - SZZ(I)*DZZ(I) + QJZ
              RVV(I) = - SVV(I)*DVV(I) + QJV
              KOJ(I) = KCFFJ
        IF (IMJ(I) .EQ. 0) GO TC 16600
              NMJ = NMJ + 1
              KOMJ(NMJ,NITF) = KCFFJ
16600   CONTINUE
COMMENT - CALL SUBROUTINE DJSTSM TO OBTAIN THE SHEAR MCMENT AT EACH
COMMENT - JOINT
        DO 16700 I = 1,NJT
              SHMO(I) = 0.0
        IF (JST(I) .EQ. 0) GO TC 16700
     CALL     DJSTSM (I,STFJ,SHMCJ)
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          IF (IRVRSE .NE. 0) GO TO 16700
                SHMO(I) = SHMOJ
 16700    CONTINUE
          IF ( IRVRSE .NE. 0 ) GO TO 17300
COMMENT - COMPUTE FOR EACH JOINT - THE SUM OF APPLIED JOINT LOAD
COMMENT - AND THE REACTION - WHEN THE APPROPRIATE MEMBER END FORCES ARE
COMMENT - SUBTRACTED FROM THIS SUM THE RESULT IS THE JOINT EQUILIBRIUM
COMMENT - ERRORS.FOR JOINT SHEAR OPTION SUBTRACT THE FORCES THAT ARE
COMMENT - CARRIED BY THE JOINT SHEAR DEFORMATION.
      DO 17250  I = 1,NJT
                ERXX(I) = QXX(I) + RXX(I)
          IF(DABS(QXX(I)) .GE. 1.0E+15) ERXX(I) = 0.0
                ERYY(I) = QYY(I) + RYY(I)
          IF(DABS(QYY(I)) .GE. 1.0E+15) ERYY(I) = 0.0
                ERZZ(I) = QZZ(I) + RZZ(I) - SHMO(I)
          IF(DABS(QZZ(I)) .GE. 1.0E+15) ERZZ(I) = 0.0
          IF (JST(I) .NE. 0) GO TO 17000
                ERVV(I) = 0.0
          GO TO 17250
 17000    CONTINUE
                ERVV(I) = QVV(I) + RVV(I) + SHMO(I)
          IF(DABS(QVV(I)) .GE. 1.0E+15) ERVV(I) = 0.0
 17250    CONTINUE
          IF ( APROB .EQ. PRINT .OR. APROB .EQ. MEMBER ) GO TO 17260
          GO TO 17300
 17260    CONTINUE
      PRINT 155, NITF
 17300    CONTINUE
COMMENT - START NONLINEAR MEMBER SOLUTION
                IFAE = 0
                NMNC = 0
          DO 17500  JJ = 1,NM
                IMC(JJ) = 0
                NITM(JJ) = 0
COMMENT - CALL SUBROUTINE MEMSOL FOR ITERATIVE SOLUTION OF MEMBER TO
COMMENT - FIND MEMBER-END-FORCES FOR JOINT EQULIBRIUM CHECK IN FRAME
COMMENT - SOLUTION
      CALL      MEMSOL (     EM,RC,W,SL,L1,L3,L4,L6)
          IF (IMC(JJ) .EQ. 1)  NMNC = NMNC + 1
 17500    CONTINUE
          IF ( IRVRSE .EQ. 0 ) GO TO 17600
COMMENT - SAVE JOINT DISPLACEMENTS (ONLY) FROM THIS FIRST ITERATION
COMMENT - FOR MONITOR JOINTS
                NMJ = 0
          DO 17650 I = 1,NJT
          IF ( IMJ(I) .EQ. 0 ) GO TO 17650
                NMJ = NMJ + 1
                DXXMJ(NMJ,1) = DXX(I)
                DYYMJ(NMJ,1) = DYY(I)
                DZZMJ(NMJ,1) = DZZ(I)
                DVVMJ(NMJ,1) = DVV(I)
 17650    CONTINUE
COMMENT - RETURN FOR THE ADDITIONAL FRAME ITERATION(REVERSAL CASE)
          GO TO 5100
 17600    CONTINUE
                NMJ = 0
COMMENT - SAVE JOINT DISPLACEMENTS AND EQUILIBRIUM ERRORS FROM THIS
COMMENT - ITERATION FOR MONITOR JOINTS
          DO 17700 I = 1,NJT
          IF (IMJ(I) .EQ. 0) GO TO 17700
                NMJ = NMJ + 1
                ERXXMJ(NMJ,NITF) = ERXX(I)
                ERYYMJ(NMJ,NITF) = ERYY(I)
                ERZZMJ(NMJ,NITF) = ERZZ(I)
                ERVVMJ(NMJ,NITF) = ERVV(I)
                DXXMJ(NMJ,NITF) = DXX(I)
                DYYMJ(NMJ,NITF) = DYY(I)
                DZZMJ(NMJ,NITF) = DZZ(I)
                DVVMJ(NMJ,NITF) = DVV(I)
 17700    CONTINUE
COMMENT - COMPUTE NUMBER OF JOINTS NOT CLOSED --- SKIP CHECKS CORRESPOND
COMMENT - ING TO SPECIFIED DISPLACEMENTS
                NJNC = 0
          DO 18700  I = 1,NJT
          IF(DABS(ERXX(I)) .GT. ERR1 .AND.DABS(QXX(I)) .LT. 1.0E+15)
     2               GO TO 18600
          IF(DABS(ERYY(I)) .GT. ERR1 .AND.DABS(QYY(I)) .LT. 1.0E+15)
     2               GO TO 18600
          IF(DABS(ERZZ(I)) .GT. ERR2 .AND.DABS(QZZ(I)) .LT. 1.0E+15)
     2               GO TO 18600
          IF(DABS(ERVV(I)) .GT. ERR2 .AND.DABS(QVV(I)) .LT. 1.0E+15)
     2               GO TO 18600
          GO TO 18700
 18600          NJNC = NJNC + 1
 18700    CONTINUE
          IF (NJNC .EQ. 0) GO TO 18900
      PRINT 175, NJNC,NITF
          IF ( NITF .EQ. MNITF) GO TO 18950
          IF (NMNC .GT. 0)  GO TO 18950
COMMENT - RETURN FOR NEXT FRAME ITERATION
          GO TO 5100
 18900    CONTINUE
          IF ( APROB .EQ. PRINT .OR. APROB .EQ. MEMBER ) GO TO 18920
          GO TO 18950
 18920    CONTINUE
      PRINT 177, NITF
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18950      CONTINUE
           IF (NMNC .GT. 0)  PRINT 185, NMNC, NITF
COMMENT - PRINT SUMMARY CF FRAME ITTERATICNS
     PRINT  231
                NMJ = 0
                KASTER = 0
           DO 18960  I = 1,NJT
           IF (IMJ(I) .EQ. 0) GO TO 18960
                NMJ = NMJ + 1
           DO 18955  J = 1,NITF
           IF (KOMJ(NMJ,J) .EQ. 1) GO TO 18952
       PRINT 232, I,J,DXXMJ(NMJ,J),DYYMJ(NMJ,J),DZZMJ(NMJ,J),
     2     DVVMJ(NMJ,J),ERXXMJ(NMJ,J), ERYYMJ(NMJ,J), ERZZMJ(NMJ,J),
     3     ERVVMJ(NMJ,J)
           GO TO 18955
18952           KASTER = 1
      PRINT 233, I,J,DXXMJ(NMJ,J),DYYMJ(NMJ,J),DZZMJ(NMJ,J),
     2     DVVMJ(NMJ,J),ERXXMJ(NMJ,J), ERYYMJ(NMJ,J), ERZZMJ(NMJ,J),
     3     ERVVMJ(NMJ,J)
18955      CONTINUE
18960      CONTINUE
           IF (KASTER .EQ. 1) PRINT 184
           IF ( APROB .EQ. PRINT .OR. APROB .EQ. MEMBER ) GO TO 18961
           GO TO 88962
18961      CONTINUE
           IF ( ITYPE .EQ. 1 ) GO TO 88962
     PRINT 196
88962      CONTINUE
COMMENT - PRINT TABLE 8 IF REQUESTED
           IF (IP8 .EQ. 1) GO TO 18970
     PRINT 11
     PRINT 16,NPROB,(AN2(II),II=1,9)
           IF (NJNC .GT. 0 .OR. NMNC .GT. 0)  PRINT 777
     PRINT 234
                KASTER = 0
                TEMPXX = 0.0
                TEMPYY = 0.0
                TEMPZZ = 0.0
                TEMPVV = 0.0
           DO 18967 I = 1,NJI
                SHMOJ = -SHMO(I)
           IF (KOJ(I) .EQ. 1) GO TO 18962
       PRINT 235, I, DXX(I), DYY(I), DZZ(I),DVV(I), RXX(I), RYY(I),
     2     RZZ(I),RVV(I), SHMO(I), SHMOJ
           GO TO 18963
18962           KASTER = 1
      PRINT 236, I, DXX(I), DYY(I), DZZ(I),DVV(I), RXX(I), RYY(I),
     2     RZZ(I),RVV(I), SHMO(I), SHMOJ
18963      CONTINUE
           IF ( DABS(QXX(I)).GE. 1.0D+15 ) GO TO 18964
                TEMPXX = TEMPXX + RXX(I)
18964      CONTINUE
           IF ( DABS(QYY(I)).GE. 1.0D+15 ) GO TO 18965
                TEMPYY = TEMPYY + RYY(I)
18965      CONTINUE
           IF ( DABS(QZZ(I)).GE. 1.0D+15 ) GO TO 18966
                TEMPZZ = TEMPZZ + RZZ(I)
18966      CONTINUE
           IF ( DABS(QVV(I)).GE. 1.0D+15 ) GO TO 18967
                TEMPVV = TEMPVV + RVV(I)
18967      CONTINUE
     PRINT 237, TEMPXX, TEMPYY, TEMPZZ,TEMPVV
           IF (KASTER .EQ. 1) PRINT 154
18970      CONTINUE
COMMENT - PRINT TABLE 9 IF REQUESTED
COMMENT - EVEN WHEN NOT REQUESTED, SUBROUTINE  PRINT9 MUST STILL BE
COMMENT - ACCESSED (TO TAKE CARE CF TYPE 9 PROBLEM ), BUT DETAILED
COMMENT - PRINTING OF MEMBER RESULTS WILL BE AVOIDED
     REWIND N1
     REWIND N2
                NT = N1
                N1 = N2
                N2 = NT
COMMENT - SUBROUTINE PRINT9 OUTPUTS MEMBER RESULTS
     CALL        PRINT9 (AN2,NPROB,RM,RO,W,SL,L1,L3,L4,L6)
18980      CONTINUE
COMMENT - PRINT TABLE 10 (JOINT ECUILIBRIUM ERRORS)IF REQUESTED
           IF (IP10 .EQ. 1) GO TO 8990
     PRINT 11
     PRINT 16,NPROB,(AN2(II),II=1,9)
           IF (NJNC .GT. 0 .OR. NMNC .GT. 0)  PRINT 777
     PRINT 238
     DO 18985  I = 1,NJT
18985 PRINT 235, I, ERXX(I), ERYY(I), ERZZ(I),ERVV(I)
 8990 CONTINUE
           IF (NMNC .GT. 0 .OR. NJNC .GT. 0) GO TO 9800
COMMENT - RETURN FOR NEW PROBLEM
 9000      GO TO 1010
 9800      CONTINUE
                NLR = NLR + 1
           IF ( NLR .LE. NLRA ) GO TO 1450
 9805      CONTINUE
COMMENT - SOLUTION IS ABANDONED
     PRINT 50
 9810 READ 12,NPROB,(AN1(II),II=1,18)
           IF (NPROB(1) .EQ. IIEST1) GO TO 9900
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      PRINT 22,NPROB,(AN1(II),II=1,18)
         GO TO 9810
 9900    CONTINUE
      RETURN
      END


************************************ SUBROUTINE ******************************
      SUBROUTINE DYNA (RM, RO, W, SL, I1, L3, L4, L6, DELWJT )
COMMENT - SUBROUTINE DYNA PERFORMS DYNAMIC ANALYSIS FOR FRAMES THAT DO
COMMENT - NOT INCLUDE JOINT SHEAR DEFORMATION EFFECTS.
      IMPLICIT REAL*8 (A-H,O-Z)
      REAL*8 MEMBER
      REAL*4 DISJT
      REAL*4 FORCEL, STRANL, BMOMNL, CURVAL, SHFORL, GAMMAL,
     2       FORCER, STRANR, BMOMNR, CURVAR, SHFORR, GAMMAR,
     3       FRMAXF, FRMAXD, FRMMCM, FRMRCT, FRMSHF,FRMLTD,
     4       TOAXF,  TOAXD,  TOMOM,  TOROT,  TOSHF, TOLTD,
     5       SHMJT
      REAL*4 FOMTEM
      DIMENSION SMMT(21)
      DIMENSION FOMT(6)
      DIMENSION FOMTEM(50,6)
      DIMENSION TR(71)
      DIMENSION RM(L6,L4), RO(L6), W(L6)
      DIMENSION DELWJT (L6)
      COMMON /BLOCK1/ X(25),        Y(25),        QXX(25),      QYY(25),
     2     QZZ(25),     SXX(25),      SYY(25),      SZZ(25),      DXX(25),
     3     DYY(25),     DZZ(25),      RXX(25),      RYY(25),      RZZ(25),
     4     ERXX(25),    ERYY(25),     ERZZ(25),     QMJ(25),      WMJ(25),
     5     NSXX(25),    NSYY(25),     NSZZ(25),     IMJ(25),      NSXP(25),
     6     NSYP(25),    ISTJR(25)
      COMMON /BLOCK2/ DXS( 25),     DYS( 25),     ZLS( 25),     DC1S( 25),
     2     DC2S( 25),   PRF( 25),     PRAE( 25),    QM( 25),      WM( 25),
     3     PRAG(25),    ELEMN(25),
     4     IOPOP( 25),  IPINL( 25),   IPINR( 25),   NC51( 25),    INLOP( 25),
     5     NAL( 25),    NSXL( 25),    NSYL( 25),    NSZL( 25),    NAR( 25),
     6     NSXR( 25),   NSYR( 25),    NSZR( 25),    NCDS( 25),    IAXOPS( 25)
      COMMON /BLOCK4/ FOMM(50,6),SMC(50,21),IST(50),   LT(50),
     2     JT1(50),     JT2(50),      NITM(50),     IMM(50),      IMC(50)
      COMMON /BLOCK7/ F( 22),       AE( 22),      SX( 22),      SY( 22),
     2     SZ( 22),     QX( 22),      QY( 22),      QZ( 22),      DX( 22),
     3     DY( 22),     DZ( 22),      ERX( 22),     ERY( 22),     ERZ( 22),
     4     SQX( 22),    SQY( 22),     SQZ( 22),     U1( 22),      V1( 22),
     5     W1( 22),     U2( 22),      V2( 22),      W2( 22),      DS(3,3, 22),
     6     BM1S( 22),   BM2S( 22),    TTS( 22),     AG( 22)
      COMMON /BLOC1/ ZMASS(25),FTMJXX(25),FTMJYY(25),FTMJZZ(25),
     2     FTMJVV(25),TTMJ(25),NFTXX(25),NFTYY(25),NFTZZ(25),NFTVV(25)
      COMMON /BLOC16/ ERXXMJ(5,25),ERYYMJ(5,25),ERZZMJ(5,25),
     2     DXXMJ(5,25),DYYMJ(5,25),DZZMJ(5,25),KOMJ(5,25),KOJ(25)
      COMMON /BLOC21/ ACCJT(100),VELJT(100),ZMASSR(100),DACCJT(100),
     2     DVELJT(100),FACCJT(100),FDAMJT(100),CDAMP(100),DISJT(80,71)
      COMMON /BLOC22/ FJXT(25),FJYT(25),FJZT(25),FJVT(25),
     2     DFJXT(25),DFJYT(25),DFJZT(25),DFJVT(25)
      COMMON /BLOC23/ DFFS(4,25)
      COMMON/BLOC24/   AN1(40),AN2(11),NPROB(2)
      COMMON /BLK1/   TOL,     ELEMNT,NJST,  KEEP3C,NCD3C,
     2           KEEP2, KEEP3A,KEEP3B,KEEP4A,KEEP4B,KEEP4C,KEEP5A,
     3           KEEP5B,KEEP5C,KEEP5D,KEEP6, KEEP7, NCD2,  NCD3A,
     4           NCD3B, NCD4A, NCD4B, NCD4C, NCD5A, NCD5B, NCD5C,
     5           NCD5D, NCD6,  NCD7,  IP8,   IP9,   IP10,  ITYPE,
     6           IABAN, IFORM, NM,    NJT,   NST,   NLT,   M,
     7           MP1,   MP2,   ISIT,  LTT,   ITYPEL,IDJ,   NSTL
      COMMON /BLK3/ MNJT,MNST,MNLT,MNM,MNC5,MNC6,MDJT,MNJS,MNE,MNCS,
     2     MNPCS,MNSS,MNQWM,MNJST,MNJSS
      COMMON /BLK5/ NFSUB,NITF,N1,N2
      COMMON /BLK7/ INLOPT,IPAE,KOFFJ,KOFFQW,KOFFSE
      COMMON / RI / NL, ML, J1
      COMMON/ITC/ ERR1,ERR2,ER1,ER2,DTI,CM,NTI,MM(20),MJ(20),MNITF,
     2           MNITM,NSMJ,NSMM
      COMMON /WARN/ NJNC,NMNC
      COMMON /NIT/ APROB
      COMMON /SKT2/      WRX(25,10),  WRY(25,10),  WRZ(25,10),
     2     WRV(25,10),  WRXP(25,10), WRYP(25,10), WRTX(25,10),
     3     WRTY(25,10), WRTZ(25,10), WRTV(25,10), WRTXP(25,10),
     4     WRTYP(25,10)
      COMMON /SKT3/ NCOUNT, NITERF
      COMMON /SKT5/          WRXM (21,10),  WRYM (21,10),  WRZM (21,10),
     2                       WRTXM(21,10),  WRTYM(21,10),  WRTZM(21,10)
      COMMON /SKT6/          NITERM(50), INDEX
      COMMON /SKT11/         MSSINL,        MSSIM1
      COMMON /SKT13/         EPR1S(21,10,3),EPRT1S(21,10,3),
     2                       EPR2S(21,10,3),EPRT2S(21,10,3)
      COMMON /SKT14 / IRV(21,2,10),                    FOMOLD(50,6),
     2               IRVRSE,       ITAPE,              N3
      COMMON /SKT15/  JJ
      COMMON /SKT17/  N4
      COMMON /SKT18/ NCHECK
      COMMON /SKT19/ JCRGCN(25,6), JCUREV(25,6)
      COMMON /SKT20/ MCRGCN(21,3), MCUREV(21,3)
      COMMON /SKT21/ NTR, NTRA
      COMMON /SKT22/ TIME, JT, IRDYN, IRSTEP(71)
      COMMON /SKT26/ LTYPEL
      COMMON /SKT27/ IREAD, IWRITE
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      COMMON /SKT28/ FORCEL(20,71),STRANL(20,71),BMOMNL(20,71),
     2      CURVAL(20,71),FCRCER(20,71),STRANR(20,71),BMOMNR(20,71),
     3      CURVAR(20,71),FRMAXF(20,71),FRMAXD(20,71),FRMMOM(20,71),
     4      FRMROT(20,71),FRMSHF(20,71),FRMLTD(20,71),TOAXF(20,71),
     5      TOAXD(20,71), TOMOM(20,71), TOROT(20,71), TOSHF(20,71),
     6      TOLTD(20,71)
      COMMON /SKT30/ MSTIF(25), MLOAD(25), MODEL(25)
      COMMON /SKT32/ EPBF1 (21,10,3), EPBFT1(21,10,3), SLBF1 (21,10,3),
     2               SLBFT1(21,10,3), EPBF2 (21,10,3), EPBFT2(21,10,3),
     3               SLBF2 (21,10,3), SLBFT2(21,10,3),
     4               EPSMAX(21,2,10), EPSMIN(21,2,10), EPSPRE(21,2,10),
     5               YGROW (21,2,10), YTGROW(21,2,10)
      COMMON /SKT34/ ERXXDN(25), ERYYDN(25), ERZZDN(25), ERVVDN(25)
      COMMON /SKT35/ TMESTP
      COMMON /GT/ MJO
      COMMON /CHA28/ SHFORL(20,71),GAMMAL(20,71),SHFORR(20,71),
     2     GAMMAR(20,71),SHMJT(20,71)
      DATA PRINT /4HRINT/,PRNTNO /4HPRNO/, SAVE /4HSAVE/
      DATA MEMBER /4HMBER/
      DATA ANOW/4HANOW/,ANEW/4HANEW/
      DATA SHEAR /5HSHEAR/
   11 FORMAT  (  5H1    ,80X , 10HI-----TRIM  )
   12 FORMAT ( 20A4 )
   16 FORMAT  (///,  17H      PROB (CONTD),/,5X,A4,A1,10X,A5,7A8,A4,///)
   18 FORMAT (///,4X, 30HRESULTS AT END OF TIME STEP = ,I5, 8H   AND  ,
     2              8H TIME = ,F10.5,///)
   20 FORMAT(41HDYNAMIC SOLUTION FAILED TO CONVERGE AFTER,
     2        10H ITERATION,I3)
   40 FORMAT (//,25X,10HTIME STEP ,I3,5X,7HTIME = ,F10.4,//)
   41 FORMAT (1H1)
   50 FORMAT (     51H      SOLUTION ABANDONED IN SEARCH OF AN INDEPENDENT
     2 ,           10H PROBLEM  ,////,
     3             49H      THE FOLLOWING CARDS WERE DISCARDED IN SEARCH,
     4             //)
   90 FORMAT (////  )
   92 FORMAT (///,39H DYNAMIC SOLUTION FAILED AT TIME STEP =,I5,
     2             14H     AND TIME =,F10.5,///)
   94 FORMAT (///,48H DYNAMIC SOLUTION FAILED WHILE TRYING TO PROCEED,
     2        21H TO NEXT TIME STEP = ,I5,14H     AND TIME =,F10.5,///)
   96 FORMAT (////,42H AVAILABLE RESULTS OF THE LAST STORED GOOD,
     2             45H SOLUTION,NOT NECESSARILY LAST GOOD SOLUTION,,//,
     3             18H ARE PRINTED BELOW,///)
   98 FORMAT ( //  )
   99 FORMAT (/,  11(1PE11.3),/,  10(1PE11.3),/, 6(1PE11.3) )
  100 FORMAT ( 3(1PE14.4) )
  110 FORMAT (     31H JOINT DISPLACEMENTS AT TIME = ,F10.4,//)
  120 FORMAT (     31H JOINT VELOCITIES    AT TIME = ,F10.4,//)
  130 FORMAT (     31H JOINT ACCLERATIONS  AT TIME = ,F10.4,//)
  151 FORMAT (5X,45HTABLE 8 - JOINT DISPLACEMENTS AND REACTIONS   ,///,
     4   5X,3HJNT,4X,7HDISP(X),8X,7HDISP(Y),6X,11HROTATION(Z),3X,
     5   8HREACT(X),3X,8HREACT(Y),3X,8HREACT(Z),//)
  152 FORMAT  (3X,      I5,  3(1PE15.7),  3(1PE11.3) )
  153 FORMAT  (3X,1H*,I4,3(1PE15.7),3(1PE11.3))
  154 FORMAT (//,48H       * INDICATES JOINT SUPPORT OFF Q-W CURVE AT,
     2            20H END OF THIS PROBLEM)
  155 FORMAT (///30H        ***** FRAME ITERATION NO ,I5,6H *****,//,
     2       5X,     43H MEMB MEMB          MEMBER DISPLACEMENTS      ,
     3      11X,     25H MEMBER EQULIBRIUM ERRORS,/,
     4       5X,     46H  NO  ITER         AXIAL  LATERAL  ROTATIONAL    ,
     5       3X,     32H AXIAL      LATERAL    ROTATIONAL)
  157 FORMAT (52X,3(11H -----------),//,48X,5HTOTAL,3(1PE11.3),
     2  //,      52X,3(11H -----------))
  162 FORMAT (39H        TABLE 10 - JOINT EQULIBRIUM ERRORS,///,
     2 4X,  5HJOINT,3X,6HERR(X),9X,6HERR(Y),12X,6HERR(Z),/,
     3 12X,5HFORCE,10X,5HFORCE,13X,6HMOMENT,//)
  192 FORMAT (     50H **ATTEMPTED DIVISION BY ZERO IN JOINT SOLUTION **)
  195 FORMAT (//,96X,  34H-----REVERSAL HAS BEEN SENSED----- )
  200 FORMAT (1H1,20(/),40H   THIS IS AUTO TIME STEP REDUCT. PROBLEM
     2   , 10(/) )
  205 FORMAT (1H1,/,1X,14HMEMBER NUMBER ,I3,2X,19HMEMBER RESPONSES IN ,
     2 56H THE DIRECTION OF ORIGINAL GEOMETRY - RECORDED HYSTERSIS,//)
  206 FORMAT (1X,16HMEMBER NUMBER = ,I3,26H--MEMBER RESPONSE AT THE  ,
     2          10HLEFT END--)
  207 FORMAT (1X,16HMEMBER NUMBER = ,I3,26H--MEMBER RESPONSE AT THE ,
     2          11HRIGHT END--)
  210 FORMAT (20X,25H---- AT THE LEFT  END ---,/)
  211 FORMAT (20X,25H---- AT THE RIGHT END ---,/)
  212 FORMAT (1X, 4HTIME,/,37H STEP     TIME     AX.FORCE   AX.DISPL ,
     2          43H   MOMENT     ROTATION    SH.FORCE  LAT.DISPL,/)
  220 FORMAT (1H1,/,1X,14HMEMBER NUMBER ,I3,2X,19HSECTION RESPONSE IN,
     2 56H THE DIRECTION OF DEFORMED GEOMETRY - RECORDED HYSTERSIS,//)
  221 FORMAT (16HMEMBER NUMBER = ,I3,25H-RESPONSE OF THE SECTION ,
     2        27HCLOSEST TO THE -FROM- JOINT)
  222 FORMAT (16HMEMBER NUMBER = ,I3,25H-RESPONSE OF THE SECTION ,
     2        27HCLOSEST TO THE  -TO-  JOINT)
  230 FORMAT (1X, 4HTIME,/,37H STEP     TIME      AX.FORCE   AX.STRAIN,
     2          22H   MOMENT     CURVATURE,/)
  250 FORMAT (//,51H ** PRINT OPTION IS LIMITED TO # OF MEMBERS * # OF ,
     2          16H TIME STEPS = 30,//)
  251 FORMAT (20X,47H---------- SECTION CLOSEST TO THE  -FROM-  JOINT,/)
  252 FORMAT (20X,47H---------- SECTION CLOSEST TO THE   -TO-   JOINT,/)
  253 FORMAT (1X, 4HTIME,/,37H STEP     TIME      AX.FORCE   AX.STRAIN,
     2          44H   MOMENT     CURVATURE  SH.FORCE   SH.STRAIN,/)
  254 FORMAT (1X,I3,7(1PE11.3))
  255 FORMAT (2I3,F6.3,6(1PE10.3))
  256 FORMAT (1X,15HJOINT NUMBER = ,I3,28H--RECORDED DISPLACEMENTS--  )
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257 FORMAT (2I3,F6.3,5(1PE12.5))
260 FORMAT (    15H CHECK THE DATA)
777 FORMAT (    48H       ***  SOLUTION DID NOT CLOSE - STUDY MONITOR,
   2           10H DATA *** )
            NTEMP = NTI * NM
        IF ( APROB .NE. PRINT ) GO TO 400
        IF ( NTEMP .LE. 30 )    GO TO 400
            PRINT = PRNTNO
     PRINT 250
 400      CONTINUE
            TEMP = NTI
            TOTTME = TEMP * DTI
            NTR = 0
     NJTT = 3*NJT
        DO 500 I = 1,NJT
        IF(ZMASS(I).GE.0.0) GO TO 410
            ZMASSR(3*I-2)=-ZMASS(I)
            ZMASSR(3*I-1)=0.0
            ZMASSR(3*I)=0.0
        GO TO 500
 410        ZMASSR(3*I-2) = ZMASS(I)
            ZMASSR(3*I-1) = ZMASS(I)
            ZMASSR(3*I) = 0.0
 500      CONTINUE
        DO 550 I = 1,NJTT
            CDAMP(I)=CM*ZMASSR(I)
        IF (DABS(ZMASSR(I)) .GE. 1.0E+15) CDAMP(I)=0.0
 550      CONTINUE
        IF (ITYPE .EQ. 4 )GO TO 900
        DO 600 I = 1,NJTT
            VELJT(I) = 0.0
 600 CONTINUE
            TIME = 0.0
 900      CONTINUE
            DSS1 = 4.0/DTI
            DSS2 = DSS1/DTI
COMMENT - IF THIS IS A CONTINUATION OF TYPE# 9 PROBLEM, THEN VALUES
COMMENT - MUST BE READ FROM UNIT 'IREAD'
        IF ( ITYPEL .EQ. 9 ) GO TO 940
COMMENT - IF THIS IS A NORMAL CONTINUATION OF TYPE 1 OR TYPE 2 PROBLEM
COMMENT - THEN UNIT 'IREAD' IS NOT READ
        IF ( ITYPEL .LE. 2 ) GO TO 1000
COMMENT - IF THIS IS A NORMAL CONTINUATION OF TYPE 3 OR TYPE 4 PROBLEM
COMMENT - THEN UNIT 'IREAD' IS NOT READ
        IF ( NTR .EQ. 0 ) GO TO 1000
 940      CONTINUE
     REWIND 13
     READ (13) IREAD
        IF ( IREAD .EQ. 11 ) IWRITE = 12
        IF ( IREAD .EQ. 12 ) IWRITE = 11
COMMENT - READ OFF UNIT 'IREAD'
     REWIND IREAD
     READ ( IREAD ) ( DXX(I), DYY(I) , DZZ(I), I=1,NJT )
        DO 942 I = 1,NJT
            NTEMP = NSXX(I) + NSYY(I) + NSZZ(I) + NSXP(I) + NSYP(I)
        IF ( NTEMP .EQ. 0 ) GO TO 942
     READ (IREAD )   (WRX(I,J),WRTX(I,J),WRY(I,J),WRTY(I,J),WRZ(I,J),
   2            WRTZ(I,J),WRXP(I,J),WRTXP(I,J),WRYP(I,J),WRTYP(I,J),
   3             J = 1,10 )
 942      CONTINUE
COMMENT - INITIALISE REVERSAL INDICATORS FOR JOINT CURVES
        DO 945  I = 1,MNJT
        DO 945  N = 1,5
            JCUREV(I,N) = 0
 945      CONTINUE
COMMENT - IF THE LAST GOOD SOLUTION STORED ON UNIT 'IREAD' WAS ENDING IN
COMMENT - STATIC ANALYSIS THEN, VELOCITIES ETC. ARE NOT APPLICABLE
        IF ( ITYPEL .EQ. 9 .AND. ITYPE .EQ. 3 ) GO TO 950
     READ  ( IREAD  ) JT, TIME, ( VELJT(I) , I=1,NJTT )
     READ  ( IREAD ) ( ACCJT(I), I=1,NJTT )
 950      CONTINUE
     REWIND N2
     REWIND N4
        DO 980 JJ = 1,NM
            ISTT = IST(JJ)
        IF ( ISTT .EQ. 0 ) GO TO 980
            MODELT = MODEL(ISTT)
            ELEMNT = ELEMN(ISTT)
            NHINGE = 2
            M = MSTIF (ISTT)
           MP1= M+1
           MP2= M+2
     READ ( IREAD ) ( DX(I), DY(I), DZ(I), I=1,MP2 )
     WRITE(N2) ( DX(I) , DY(I), DZ(I) , I=1,MP2 )
        IF ( INLOP(ISTT) .EQ. 0 ) GO TO 980
            NREAD = NSXL(ISTT)+NSYL(ISTT)+NSZL(ISTT)
        IF ( NREAD .EQ. 0 ) GO TO 952
     READ (IREAD )  ((WRXM(I,J),WRTXM(I,J),WRYM(I,J),WRTYM(I,J),
   2            WRZM(I,J), WRTZM(I,J), J=1,10), I=2,MP1 )
     WRITE (N2) (( WRXM(I,J), WRTXM(I,J), WRYM(I,J), WRTYM(I,J),
   2            WRZM(I,J), WRTZM(I,J), J=1,10), I=2,MP1 )
 952      CONTINUE
        IF ( MODELT .LE. -1 ) GO TO 954
        IF (ELEMNT .EQ. SHEAR) GO TO 953
     READ (IREAD )  (((EPR1S(I,J,K),EPRT1S(I,J,K),EPR2S(I,J,K),
   2               EPRT2S(I,J,K),K=1,MSSIM1), J=1,MNPCS), I=2,MP1 )
```

```
    WRITE (N2) ((( EPR1S(I,J,K), EPRT1S(I,J,K), EPR2S(I,J,K),
   2                 EPRT2S(I,J,K),K=1,MSSIM1), J=1,MNPCS), I=2,MP1 )
          IF ( MODELT .EQ.  0 ) GO TO 954
    READ  (IREAD ) (((EPBF1  (I,J,K), EPBFT1(I,J,K), SLBF1  (I,J,K),
   2                  SLBFT1(I,J,K), EPBF2  (I,J,K), EPBFT2(I,J,K),
   3                  SLBF2  (I,J,K), SLBFT2(I,J,K), K=1,MSSIM1 ),
   4                  J = 1,MNPCS ), I = 2,MP1 )
    WRITE (N2    ) (((EPBF1  (I,J,K), EPBFT1(I,J,K), SLBF1  (I,J,K),
   2                  SLBFT1(I,J,K), EPBF2  (I,J,K), EPBFT2(I,J,K),
   3                  SLBF2  (I,J,K), SLBFT2(I,J,K), K=1,MSSIM1 ),
   4                  J = 1,MNPCS ), I = 2,MP1 )
          GO TO 95301
  953     CONTINUE
              NHINGE = 1
    READ (IREAD ) (((EPR1S(I,J,K),EPRT1S(I,J,K),
   2                K = 1,MSSIM1), J=1,MNPCS), I=2,MP1 )
    WRITE (N2) ((( EPR1S(I,J,K), EPRT1S(I,J,K),
   2                K = 1,MSSIM1), J=1,MNPCS), I=2,MP1 )
          IF ( MODELT .EQ.  0 ) GO TO 954
    READ  (IREAD ) (((EPBF1  (I,J,K), EPBFT1(I,J,K), SLBF1  (I,J,K),
   2                  SLBFT1(I,J,K), K=1,MSSIM1 ),J=1,MNPCS),I=2,MP1)
    WRITE (N2    ) (((EPBF1  (I,J,K), EPBFT1(I,J,K), SLBF1  (I,J,K),
   2                  SLBFT1(I,J,K), K=1,MSSIM1 ),J=1,MNPCS),I=2,MP1)
95301     CONTINUE
    READ  (IREAD ) (((EPSMAX(I,L,J), EPSMIN(I,L,J), EPSPRE(I,L,J),
   2                  J = 1,MNPCS ), L = 1,NHINGE ), I = 2,MP1 )
    WRITE (N2    ) (((EPSMAX(I,L,J), EPSMIN(I,L,J), EPSPRE(I,L,J),
   2                  J = 1,MNPCS ), L = 1,NHINGE ), I = 2,MP1 )
          IF ( MODELT .NE.  2 ) GO TO 954
    READ  (IREAD ) (((YGROW  (I,L,J), YTGROW(I,L,J), J = 1,MNPCS ),
   2                  L = 1,NHINGE ), I = 2,MP1 )
    WRITE (N2    ) (((YGROW  (I,L,J), YTGROW(I,L,J), J = 1,MNPCS ),
   2                  L = 1,NHINGE ), I = 2,MP1 )
  954     CONTINUE
          IF ( NREAD .EQ. 0 ) GO TO 958
          DO 955 I = 2,MP1
          DO 955 N = 1,3
              MCUREV(I,N) = 0
  955     CONTINUE
    WRITE (N4) ((MCUREV(I,N), N=1,3), I=2,MP1 )
  958     CONTINUE
          IF ( MODELT .LE. -1 ) GO TO 980
          DO 960 I = 2,MP1
          DO 960 L = 1,NHINGE
          DO 960 J = 1,MNPCS
              IRV(I,L,J) = 0
  960     CONTINUE
    WRITE (N4) ((( IRV(I,L,J), J=1,MNPCS), L=1,NHINGE), I=2,MP1 )
  980     CONTINUE
 1000     CONTINUE
          IF ( NTR .NE. 0 ) GO TO 1020
              TOTTME = TOTTME + TIME
 1020     CONTINUE
              LTYPEL = ITYPEL
              ITYPEL = ITYPE
              TIME = TIME - DTI
              IABAN = 0
              NJNC = 0
              NTI1 = NTI + 1
          DO 1030 I = 1,NTI1
 1030         IRSTEP(I) = 0
              JT = 0
 1040         JT = JT + 1
              TIME = TIME+DTI
          IF ( APROB .EQ. PRINT .OR. APROB .EQ. MEMBER ) GO TO 1044
          GO TO 1046
 1044     CONTINUE
          IF (JT .EQ. 1) PRINT 41
    PRINT 40,JT,TIME
 1046     CONTINUE
              NITF = 0
              NITERF = 1
              IRDYN = 0
              IRVRSE= 0
 1050     CONTINUE
          IF ( IRVRSE .EQ. 0 ) GO TO 1060
          IF ( APROB .EQ. PRINT .OR. APROB .EQ. MEMBER ) GO TO 1055
          GO TO 1060
 1055     CONTINUE
    PRINT 195
 1060     CONTINUE
              ITAPE = 1
          IF ( IRVRSE .NE. 0 ) ITAPE = 0
          IF ( ITAPE .EQ. 0 ) GO TO 1070
 1065     CONTINUE
              NT = N2
              N2 = N1
              N1 = NT
 1070     CONTINUE
              NT = N4
              N4 = N3
              N3 = NT
              NITF = NITF + 1
              NMJ = 0
              KOFFJ = 0
              NCHECK = 0
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              INDEX = 0
        IF ( ( IRSTEP(JT)+IADYN ) .NE. 0 ) GO TO 1100
        IF (NITERF .NE. 1) GO TC 1100
        IF (JT .EQ. 1) GO TO 1100
              NCHECK = 1
              INDEX = 1
 1100   CONTINUE
              IRVRSE = 0
COMMENT - SOLVE FOR JOINT REACTICNS
        DO 1250 I = 1,NJT
COMMENT - SUBROUTINE INELST CALCULATES THE RESISTIVE SPRING FORCE AND
COMMENT - THE SPRING STIFFNESS FOR THE JOINT SPRINGS FCLLOWING
COMMENT - NONLINEAR LOADING , INELASTIC UNLOADING PATH
     CALL       INELST (I,SJX,SJY,SJZ,SJV,SJXY,QJX,QJY,QJZ,QJV)
        IF ( IRVRSE .NE. 0 ) GO TO 1250
              RXX(I) = - SXX(I)*DXX(I) + QJX
              RYY(I) = - SYY(I)*DYY(I) + QJY
              RZZ(I) = - SZZ(I)*DZZ(I) + QJZ
              KOJ(I) = KCFFJ
        IF (IMJ(I) .EQ. 0) GO TC 1250
              NMJ = NMJ+1
              KOMJ(NMJ,NITF) = KCFFJ
 1250   CONTINUE
 1300   CONTINUE
              NITERF = NITERF + 1
        IF (IRVRSE .NE. 0 ) GC TO 1600
COMMENT - COMPUTE FOR EACH JOINT - THE SUM OF APPLIED JOINT LOAD
COMMENT - AND THE REACTION - WHEN THE APPROPRIATE MEMBER END FORCES
COMMENT - ARE SUBTRACTED FROM THIS SUM THE RESULT IS THE JOINT
COMMENT - EQUILIBRIUM ERRCRS
        DO 1500 I = 1,NJT
              ERXX(I) = QXX(I) + RXX(I)
        IF (DABS(QXX(I)) .GE. 1.0E+15) ERXX(I) = 0.0
              ERYY(I) = QYY(I) + RYY(I)
        IF (DABS(QYY(I)) .GE. 1.0E+15) ERYY(I) = 0.0
              ERZZ(I) = QZZ(I) + RZZ(I)
        IF(DABS(QZZ(I)) .GE. 1.0E+15) ERZZ(I) = 0.0
 1500   CONTINUE
 1600   CONTINUE
COMMENT - INITIALISE THE FOLLOWING VECTORS USED IN SUBROUTINE  ADJTER
        DC 1650 I = 1,NJT
              ERXXDN(I) = 0.0
              ERYYDN(I) = 0.0
              ERZZDN(I) = 0.0
 1650   CONTINUE
      REWIND N1
      REWIND N2
      REWIND N3
      REWIND N4
        IF ( APROB .EQ. PRINT .OR. APROB .EQ. MEMBER ) GO TO 1700
        GO TO 1710
 1700   CONTINUE
      PRINT 155, NIIF
 1710   CONTINUE
              TMESTP = ANOW
              IFAE = 0
              NMNC = 0
        DO 2000 JJ = 1,NM
              ISTT = IST(JJ)
              LTT = LT(JJ)
              IMC(JJ)=0
              NITM(JJ)=0
CCOMMENT - SKIP FOR NULL MEMBER
        IF (ISTT.EQ.0)GC TO 1850
     CALL MEMSOL ( RM, RC, W, SL, L1, L3, L4, L6 )
        IF (IMC(JJ) .EQ. 1)  NMNC = NMNC + 1
        GC TO 1950
COMMENT - SET MEMBER END FORCE-MATRIX TO NULL MATRIX FOR NULL MEMBER
 1850   DO 1900 I = 1,6
 1900         FOMM(JJ,I) = 0.0
 1950   CONTINUE
COMMENT - IF REVERSAL HAS BEEN SENSED AT THE BEGINNING OF
COMMENT - A NEW TIME STEP , THEN SKIP STIFFNESS FORMATION CALCULATIONS
COMMENT - AT THIS TIME STEP SINCE WRONG INCREMENTS HAVE ALREDY BEEN
COMMENT - ADDED TO THE JCINT DISPLACEMENTS AT THE END CF LAST TIME STEP.
COMMENT - SO EVERYTHING MUST BE BACKED UP TO THE LAST TIME STEP, CORRECT
COMMENT - STIFFNESS MUST BE FORMED AT ITS END, REVISED INCREMENTS MUST
COMMENT - BE ADDED TO JOINT DISPLACEMENTS, AND AGAIN THE NEXT TIME STEP
COMMENT - MUST BE BEGUN.
        IF ( IRVRSE .NE. 0 ) GO TO 2000
        IF (NMNC .GT. 0 ) PRINT 777
COMMENT - IF SOLUTICN FAILS FOR ANY REASON, THEN THE LAST GOOD STORED
COMMENT - SOLUTION ( NCT NECESSARILY THE LAST GOOD SOLUTICN SOLVED FOR )
COMMENT - IS READ AND RESULTS OUTPUT BEFORE PROCEEDING FURTHER
COMMENT - SIMILAR THINGS ARE DONE IN CASE OF FAILURE IN JOINT SOLUTICN
COMMENT - EITHER WITHIN THE TIME STEP OR AT A NEW TIME STEP
        IF ( NMNC .EQ. 0 ) GO TC 1955
              IABAN = 1
      PRINT 92, JT, TIME
        IF ( JT .EQ. 1 ) GO TC 11100
      GO TO 3870
 1955   CONTINUE
              INDEX = 0
              NCHECK = 0
        IF ( ISTT .EQ. 0 ) GO TC 2000
COMMENT - SUBROUTINE FORMST CALCULATES MEMBER (6 X 6) STISFNESS MATRIX
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COMMENT - AND TAKING ADVANTAGE OF SYMMETRY STORES IN COMPACT VECTOR
COMMENT - SMMT(I = 1,21)
      CALL     FORMST ( RM, RC, W, SL, SMMT, L1, L3, L4, L6, JJ )
          DO 1960 I = 1,21
 1960           SMC( JJ ,I) = SMMT(I)
 2000     CONTINUE
          IF ( IRVRSE .EQ. 0 ) GO TO 2015
COMMENT - DECREMENT TIME STEP PARAMETERS & JOINT DISPLACEMENTS,
COMMENT - VELOCITIES,AND ACCELERATIONS
                NITF        = NITF - 1
                NITERF      = NITERF - 1
                IRDYN       = 1
                IRSTEP(JT)  = 1
                JT          = JT - 1
                TIME        = TIME - DTI
          DO 2005 I = 1,NJTT
                VELJT(I)  = VELJT(I)  - DVELJT(I)
                ACCJT(I)  = ACCJT(I)  - DACCJT(I)
 2005     CONTINUE
          DO 2010 I = 1,NJT
                DXX(I)  = DXX(I)  - DELWJT(3*I - 2)
                DYY(I)  = DYY(I)  - DELWJT(3*I - 1)
                DZZ(I)  = DZZ(I)  - DELWJT(3*I)
 2010     CONTINUE
      GO TO 1050
 2015     CONTINUE
COMMENT - DUMP OF STIFFNESS MATRIX AND LOAD VECTOR,TO ACTIVATE,SET LAST
COMMENT - FIVE COLUMNS IN PROBLEM NUMBER CARD EQUAL TO PRINT
          IF ( APROE .NE. PRINT ) GO TO 2060
          DO 2050 JJ = 1,NM
          DO 2040  I = 1,6
                FOMTEM(JJ,I)  = 0.0
 2040     CONTINUE
                ISTT = IST(JJ)
          IF (ISTT.EQ.0) GO TO 2050
      PRINT 99,  ( SMC(JJ,I), I=1,21),  ( FOMTEM(JJ,I), I=1,6 )
 2050     CONTINUE
 2060     CONTINUE
          DO 3000 I = 1,NJT
          IF (NITF .GT. 1) GO TO 2900
      CALL DYSTLD  ( FJX,FJY,FJZ,FJV,TIME,I)
                FJXT(I)  = FJX
                FJYT(I)  = FJY
                FJZT(I)  = FJZ
 2900     CONTINUE
                ERXX(I)  =  FJXT(I)  +  ERXX(I)
                ERYY(I)  =  FJYT(I)  +  ERYY(I)
                ERZZ(I)  =  FJZT(I)  +  ERZZ(I)
 3000     CONTINUE
                NCHECK = 0
                INDEX = 0
          IF  ( JT .GT. 1) GO TO 3200
          IF  ( ITYPE .EQ. 4 ) GO TO 3200
          DO 3140 I = 1,NJT
          IF  ( ZMASSR(3*I-2) .GT. 1.0D-10 ) GO TO 3020
                ACCJT(3*I-2) = 0.0
          GO TO 3040
 3020           ACCJT(3*I-2)  = ERXX(I)/ZMASSR(3*I-2)
 3040     IF  ( ZMASSR(3*I-1) .GT. 1.0D-10 ) GO TO 3060
                ACCJT(3*I-1)  = 0.0
          GO TO 3080
 3060           ACCJT(3*I-1)  = ERYY(I)/ZMASSR(3*I-1)
 3080     IF  ( ZMASSR(3*I)    .GT. 1.0D-10 ) GO TO 3100
                ACCJT(3*I) = 0.0
          GO TO 3120
 3100           ACCJT(3*I)  = ERZZ(I)/ZMASSR(3*I)
 3120     CONTINUE
 3140     CONTINUE
 3200     DO 3250 I=1,NJTT
              FACCJT(I)=ZMASSR(I)*ACCJT(I)
              FDAMJT(I )=CDAMP(I)*VELJT(I)
 3250     CONTINUE
          DO 3300 I=1,NJT
                ERXX(I)=ERXX(I )-FACCJT(3*I-2)-FDAMJT(3*I-2)
          IF(DABS(FJXT(I))  .GT.  1.00E+10) ERXX(I)  = 0.0
                ERYY(I)=ERYY(I )-FACCJT(3*I-1)-FDAMJT(3*I-1)
          IF(DABS(FJYT(I))  .GT.  1.00E+10) ERYY(I)  = 0.0
                ERZZ(I)=ERZZ(I)-FACCJT(3*I)-FDAMJT(3*I)
          IF(DABS(FJZT(I))  .GT.  1.00E+10) ERZZ(I)  = 0.0
 3300     CONTINUE
          DO 3400  I = 1,NJT
          IF  (DABS(QXX(I)).LT.1.0E+15.AND.DABS(FJXT(I)).LT.1.0E+10)
     2    GO TO 3320
                ERXX(I)  = ERXXDN(I)
 3320     CONTINUE
          IF  (DABS(QYY(I)).LT.1.0E+15.AND.DABS(FJYT(I)).LT.1.0E+10)
     2    GO TO 3330
                ERYY(I)  = ERYYDN(I)
 3330     CONTINUE
          IF  (DABS(QZZ(I)).LT.1.0E+15.AND.DABS(FJZT(I)).LT.1.0E+10)
     2    GO TO 3400
                ERZZ(I)  = ERZZDN(I)
 3400     CONTINUE
COMMENT - IRDYN = 1       DENOTES THAT THE PARTICULAR TIME STEP BEING
C         EXECUTED NOW HAS ALREADY BEEN COMPLETLY SOLVED ONCE , BUT IS
C         ACCESSED  AGAIN THIS TIME ONLY FOR THE PURPOSE OF
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C           (BACKED UP) STIFFNESS FORMATION
            IF ( IRDYN .EQ. 1 ) GO TO 3950
            DO 3700 I = 1,NJT
            IF (DABS(QXX(I)).LT.1.0E+15.AND.DABS(FJXT(I)).LT.1.0E+10)
     2      GO TO 3510
            GO TO 3515
 3510       CONTINUE
            IF (DABS(ERXX(I)) .GT. ERR1) GO TO 5100
 3515       CONTINUE
            IF (DABS(QYY(I)).LT.1.0E+15.AND.DABS(FJYT(I)).LT.1.0E+10)
     2      GO TO 3520
            GO TO 3525
 3520       CONTINUE
            IF (DABS(ERYY(I)) .GT. ERR1) GO TO 5100
 3525       CONTINUE
            IF (DABS(QZZ(I)).LT.1.0E+15.AND.DABS(FJZT(I)).LT.1.0E+10)
     2      GO TO 3530
            GO TO 3700
 3530       CONTINUE
            IF (DABS(ERZZ(I)) .GT. ERR2) GO TO 5100
 3700       CONTINUE
COMMENT - PRINT TABLE 8 IF REQUESTED
COMMENT - EVEN IF NOT REQUESTED, PRINT RESULTS FOR THE LAST TIME STEP
            IF ( JT .EQ. NTI1 ) GO TO 3710
            IF ( IP8 .EQ. 0 ) GO TO 3860
            IF ((JT-1)/IP8*IP8 .NE. JT-1) GO TO 3860
 3710       CONTINUE
      PRINT 11
      PRINT 16, NPROB,(AN2(II),II=1,9)
      PRINT 18, JT,TIME
      PRINT 151
               KASTER = 0
               TEMPXX = 0.0
               TEMPYY = 0.0
               TEMPZZ = 0.0
          DO 3850 I = 1,NJT
           IF (KOJ(I) .EQ. 1) GO TO 3800
     PRINT 152,I,DXX(I),DYY(I),DZZ(I),RXX(I),RYY(I),RZZ(I)
           GO TO 3840
 3800          KASTER = 1
     PRINT 153,I,DXX(I),DYY(I),DZZ(I),RXX(I),RYY(I),RZZ(I)
 3840       CONTINUE
            IF (DABS(QXX(I)).GE.1.0E+15. OR.DABS(FJXT(I)).GE.1.0E+10)
     2      GO TO 3842
               TEMPXX = TEMPXX + RXX(I)
 3842       CONTINUE
            IF (DABS(QYY(I)).GE.1.0E+15. OR.DABS(FJYT(I)).GE.1.0E+10)
     2      GO TO 3844
               TEMPYY = TEMPYY + RYY(I)
 3844       CONTINUE
            IF (DABS(QZZ(I)).GE.1.0E+15. OR.DABS(FJZT(I)).GE.1.0E+10)
     2      GO TO 3850
               TEMPZZ = TEMPZZ + RZZ(I)
 3850 CONTINUE
      PRINT 157, TEMPXX, TEMPYY, TEMPZZ
           IF ( KASTER .EQ. 1) PRINT 154
 3860 CONTINUE
           IF ( JT .GT. 1 ) GO TO 3865
           IF ( LTYPEL .NE. 9 ) GO TO 3865
      PRINT 90
      PRINT 120, TIME
      PRINT 100, ( VELJT(I) , I = 1,NJTT )
      PRINT 90
      PRINT 130, TIME
      PRINT 100, ( ACCJT(I) , I = 1,NJTT )
 3865      CONTINUE
      REWIND N1
      REWIND N2
               NT = N1
               N1 = N2
               N2 = NT
 3870      CONTINUE
           IF ( IABAN .EQ. 0 ) GO TO 3890
      REWIND 13
      READ (13) IREAD
      REWIND IREAD
      READ ( IREAD ) ( DXX(I) , DYY(I) , DZZ(I) , I=1,NJT )
        DO 3880 I = 1,NJT
               NTEMP = NSXX(I) + NSYY(I) + NSZZ(I) + NSXP(I) + NSYP(I)
           IF ( NTEMP .EQ. 0 ) GO TO 3880
      READ (IREAD ) (WRX(I,J),WRTX(I,J),WRY(I,J),WRTY(I,J),WRZ(I,J),
     2              WRTZ(I,J),WRXP(I,J),WRTXP(I,J),WRYP(I,J),WRTYP(I,J),
     3              J = 1,10 )
 3880      CONTINUE
      READ  ( IREAD  ) JT, TIME, ( VELJT(I) , I=1,NJTT )
      READ  ( IREAD  ) ( ACCJT(I), I=1,NJTT )
               NTI1 = JT
               NTI  = NTI1 - 1
      PRINT 96
      PRINT 18, JT, TIME
 3890      CONTINUE
COMMENT - SUBROUTINE PRINT 9 OUTPUTS MEMBER RESUTS
      CALL PRINT9(AN2,NPROB,RM,RO,W,SL,L1,L3,L4,L6)
 3900      CONTINUE
         IF ( IABAN .NE. 0 ) GO TO 3950
          IF ( JT .EQ. NTI1 ) GO TO 3910
```

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              IF ( IP10 .EQ. 0 ) GO TO 3950
COMMENT - PRINT TABLE 10 IF REQUESTED
              IF ((JT-1)/IP10*IP10 .NE. JT-1) GO TO 3950
  3910        CONTINUE
        PRINT 11
        PRINT 16,NPROB, (AN2(II),II=1,9)
        PRINT 162
              DO 3940 I = 1,NJT
  3940  PRINT 152, I, ERXX(I) , ERYY(I) , ERZZ(I)
        PRINT 90
  3950        CONTINUE
              IF ( JT .EQ. NTI1 ) GO TO 10000
COMMENT - NEW TIME STEP
                   TIME2 = TIME + DTI
                   TMESTP = ANEW
        REWIND N1
                   NT = N3
                   N3 = N4
                   N4 = NT
        REWIND N3
                   IFAE   = 1
                   NCHECK = 0
                   INDEX  = 0
              DO 4000 JJ = 1,NM
                   ISTT   = IST(JJ)
                   LTT    = LT (JJ)
              IF ( ISTT .EQ. 0 ) GO TO 4000
        CALL FORMST ( RM, RC, W, SL, SMMT, L1, L3, L4, L6, JJ )
        CALL FORMLD ( RM, RC, W, SL, FCMT, L1, L3, L4, L6, JJ )
              DO 3970 I = 1,6
                   FOMM(JJ,I) = FCMT(I)
  3970        CONTINUE
  4000        CONTINUE
                   NT = N3
                   N3 = N4
                   N4 = NT
              IF ( APRCE .NE. PRINT ) GO TO 4060
        PRINT 98
              DO 4050 JJ = 1,NM
                   ISTT = IST(JJ)
              IF ( ISTT .EQ. 0 ) GO TO 4050
        PRINT 99, ( SMC(JJ,I) , I=1,21), ( FOMM(JJ,I), I=1,6 )
  4050        CONTINUE
        PRINT 98
  4060        CONTINUE
              DO 4200 I = 1,NJT
        CALL       DYSTLD (FJX,FJY,FJZ,FJV,TIME2,I)
                   DFJXT(I) = FJX - FJXT(I)
                   DFJYT(I) = FJY - FJYT(I)
                   DFJZT(I) = FJZ - FJZT(I)
  4200        CONTINUE
              IF (JT .GT. 1) GO TO 4260
              IF (NSMJ .EQ. 0) GO TO 4260
              DO 4250 II = 1,NSMJ
                   MJOINT = MJ(II)
                   DISJT  ( 3*II-2,JT  ) = DXX(MJOINT)
                   DISJT  ( 3*II-1,JT  ) = DYY(MJOINT)
                   DISJT  ( 3*II  ,JT  ) = DZZ(MJOINT)
  4250        CONTINUE
  4260        CONTINUE
              DO 4270 I = 1,NJT
                   AA1 = ACCJT(3*I-2)
                   AA2 = ACCJT(3*I-1)
                   AA3 = ACCJT(3*I)
                   VV4 = VELJT(3*I-2)
                   VV5 = VELJT(3*I-1)
                   VV6 = VELJT(3*I)
                   ITEMP=3*I-2
                   DFFS(1,I)=ZMASSR(ITEMP)*(2.0*AA1+VV4*DSS1)+DFJXT(I)
     2             +CDAMP(ITEMP)*2.0*VV4
                   ITEMP=ITEMP+1
                   DFFS(2,I)=ZMASSR(ITEMP)*(2.0*AA2+VV5*DSS1)+DFJYT(I)
     2             +CDAMP(ITEMP)*2.0*VV5
                   ITEMP=ITEMP+1
                   DFFS(3,I)=ZMASSR(ITEMP)*(2.0*AA3+VV6*DSS1)+DFJZT(I)
     2             +CDAMP(ITEMP)*2.0*VV6
  4270        CONTINUE
                   IHB = 3*IDJ+2
                   NL = 3*NJT
                   ML = 1
                   NFSUB = 21
        CALL       GRIP2A (RM,RO,W,SL,L3,L4,L6,IHB)
              IF ( IHB .LT. 10000 ) GO TO 4280
COMMENT - SYMBOLICALLY MAKE NJNC = 1
                   NJNC = 1
                   IABAN = 1
                   NTEMP = JT + 1
                   TEMP  = TIME + DTI
        PRINT 94, NTEMP, TEMP
        GO TO 3870
  4280        CONTINUE
COMMENT - COMPUTE INCREMENTS OF VELOCITY AND ACCELERATION
              DO 4300 I = 1,NJTT
                   DVELJT(I) = -2.0*VELJT(I) + 2.0*W(I)/DTI
                   DACCJT(I) = -2.0*ACCJT(I) - 4.0*VELJT(I)/DTI + DSS2*W(I)
  4300        CONTINUE
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```
          DO 4400 I = 1,NJTT
                VELJT(I) = VELJT(I) + DVELJT(I)
                ACCJT(I) = ACCJT(I) + DACCJT(I)
                DELWJT(I) = W(I)
 4400     CONTINUE
          DO 4500 I = 1,NJT
                DXX(I) = DXX(I) + W(3*I-2)
                DYY(I) = DYY(I) + W(3*I-1)
                DZZ(I) = DZZ(I) + W(3*I)
 4500     CONTINUE
          IF (NSMJ .EQ. 0) GO TO 4610
          DO 4600 II = 1,NSMJ
                MJOINT = MJ(II)
                DISJT ( 3*II-2,JT+1) = DXX(MJOINT)
                DISJT ( 3*II-1,JT+1) = DYY(MJOINT)
                DISJT ( 3*II  ,JT+1) = DZZ(MJOINT)
 4600     CONTINUE
 4610     CONTINUE
      GO TO 10000
 5100     CONTINUE
          IF (JT .NE. 1) GO TO 5110
                IABAN = 1
      PRINT 92, JT, TIME
      PRINT 260
                 GO TO 11100
 5110            CONTINUE
COMMENT - ITERATE WITHIN TIME STEP
COMMENT - ZERO DFFS - ONLY SOLVING FOR ERROR
          DO 5150 I = 1,NJT
                DFFS(1,I) = 0.0
                DFFS(2,I) = 0.0
                DFFS(3,I) = 0.0
 5150     CONTINUE
          DO 5155 JJ = 1,NM
          DO 5155  I = 1,6
                FOMM(JJ,I) = 0.0
 5155     CONTINUE
                IHB = 3*IDJ+2
                NL = 3*NJT
                ML = 1
                NFSUB = 21
      CALL GRIP2A (RM,RO,W,SL,L3,L4,L6,IHB)
          IF ( IHB .LT. 10000 ) GO TO 5160
COMMENT - SYMBOLICALLY MAKE NJNC = 1
                NJNC = 1
                IABAN = 1
      PRINT 92, JT, TIME
          IF ( JT .EQ. 1 ) GO TO 11100
      GO TO 3870
 5160     CONTINUE
          DO 5200 I = 1,NJTT
                VELJT(I) = VELJT(I) + W(I)*2.0/DTI
                ACCJT(I) = ACCJT(I) + W(I)*DSS2
 5200     CONTINUE
          DO 5300 I = 1,NJT
                DXX(I) = DXX(I) + W(3*I-2)
                DYY(I) = DYY(I) + W(3*I-1)
                DZZ(I) = DZZ(I) + W(3*I)
 5300     CONTINUE
          IF (NSMJ .EQ. 0) GO TO 5410
          DO 5400 II = 1,NSMJ
                MJOINT = MJ(II)
                DISJT ( 3*II-2,JT  ) = DXX(MJOINT)
                DISJT ( 3*II-1,JT  ) = DYY(MJOINT)
                DISJT ( 3*II  ,JT  ) = DZZ(MJOINT)
 5400     CONTINUE
 5410     CONTINUE
          IF ( NITF .LT. MNITF ) GO TO 1065
      PRINT 20,MNITF
COMMENT - SYMBOLICALLY MAKE NJNC = 1
                NJNC = 1
                IABAN = 1
      PRINT 92, JT, TIME
          IF ( JT .EQ. 1 ) GO TO 11100
      GO TO 3870
10000     CONTINUE
          IF ( JT .LT. NTI1 ) GO TO 1040
                ANTI1 = NTI1
          IF ( APROB .NE. SAVE ) GO TO 10005
      WRITE (14,12) ( AN1(II), II=1,40 )
10005     CONTINUE
          IF (NSMM .EQ. 0) GO TO 10150
          DO 10100 II = 1,NSMM
      PRINT 205, MM(II)
          IF ( APROB .NE. SAVE ) GO TO 10010
      WRITE (14,206) MM(II)
10010     CONTINUE
      PRINT 210
      PRINT 212
                TEMP = TIME - ANTI1 * DTI
          DO 10020 J = 1,NTI1
                TEMP = TEMP + DTI
      PRINT 254, J,TEMP,FRMAXF(II,J),FRMAXD(II,J),FRMMOM(II,J),
     2                  FRMROT(II,J),FRMSHF(II,J),FRMLTD(II,J)
          IF ( APROB .NE. SAVE ) GO TO 10020
      WRITE (14,255) MM(II),J,TEMP,FRMAXF(II,J),FRMAXD(II,J),
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     2                  FRMMOM(II,J),FRMRCT(II,J),FRMSHF(II,J),FRMLTD(II,J)
10020     CONTINUE
      PRINT 205, MM(II)
          IF ( APROB .NE. SAVE ) GO TO 10022
      WRITE (14,207) MM(II)
10022     CONTINUE
      PRINT 211
      PRINT 212
                TEMP = TIME - ANTI1 * DTI
          DO 10024 J = 1,NTI1
                TEMP = TEMP + DTI
      PRINT 254, J,TEMP,TOAXF(II,J),TOAXD(II,J),TOMOM(II,J),
     2                  TOROT(II,J),TOSHF(II,J),TOLTD(II,J)
          IF ( APROB .NE. SAVE ) GO TO 10024
      WRITE (14,255) MM(II),J,TEMP,TOAXF(II,J),TOAXD(II,J),
     2                  TOMOM(II,J),TOROT(II,J),TOSHF(II,J),TOLTD(II,J)
10024     CONTINUE
      PRINT 220, MM(II)
          IF ( APROB .NE. SAVE ) GO TO 10030
      WRITE (15,221) MM(II)
10030     CONTINUE
                TEMP = TIME - ANTI1 * DTI
                ISTT = IST(MM(II))
          IF (ELEMN(ISTT) .EQ. SHEAR) GO TO 10060
      PRINT 251
      PRINT 230
          DO 10050 J = 1,NTI1
                TEMP = TEMP + DTI
      PRINT 254, J,TEMP,FORCEL(II,J),STRANL(II,J),
     2                  BMOMNL(II,J),CURVAL(II,J)
          IF ( APROB .NE. SAVE ) GO TO 10050
      WRITE (15,255) MM(II),J,TEMP,FORCEL(II,J),STRANL(II,J),
     2                  BMOMNL(II,J),CURVAL(II,J)
10050     CONTINUE
      PRINT 220, MM(II)
          IF ( APROB .NE. SAVE ) GO TO 10052
      WRITE (15,222) MM(II)
10052     CONTINUE
                TEMP = TIME - ANTI1 * DTI
      PRINT 252
      PRINT 230
          DO 10054 J = 1,NTI1
                TEMP = TEMP + DTI
      PRINT 254, J,TEMP,FORCER(II,J),STRANR(II,J),
     2                  BMOMNR(II,J),CURVAR(II,J)
          IF ( APROB .NE. SAVE ) GO TO 10054
      WRITE (15,255) MM(II),J,TEMP,FORCER(II,J),STRANR(II,J),
     2                  BMOMNR(II,J),CURVAR(II,J)
10054     CONTINUE
          GO TO 10100
10060     CONTINUE
      PRINT 251
      PRINT 253
          DO 10070 J = 1,NTI1
                TEMP = TEMP + DTI
      PRINT 254,J,TEMP,FORCEL(II,J),STRANL(II,J),
     2    BMOMNL(II,J),CURVAL(II,J),SHFORL(II,J),GAMMAL(II,J)
          IF (APROB .NE. SAVE) GO TO 10070
      WRITE (15,255) MM(II),J,TEMP,FORCEL(II,J),STRANL(II,J),
     2    BMOMNL(II,J),CURVAL(II,J),SHFORL(II,J),GAMMAL(II,J)
10070     CONTINUE
      PRINT 220, MM(II)
          IF ( APROB .NE. SAVE ) GO TO 10072
      WRITE (15,222) MM(II)
10072     CONTINUE
                TEMP = TIME - ANTI1 * DTI
      PRINT 252
      PRINT 253
          DO 10080 J = 1,NTI1
                TEMP = TEMP + DTI
      PRINT 254, J,TEMP,FORCER(II,J),STRANR(II,J),
     2    BMOMNR(II,J),CURVAR(II,J),SHFORR(II,J),GAMMAR(II,J)
          IF (APROB .NE. SAVE) GO TO 10080
      WRITE (15,255) MM(II),J,TEMP,FORCER(II,J),STRANR(II,J),
     2    BMOMNR(II,J),CURVAR(II,J),SHFORR(II,J),GAMMAR(II,J)
10080     CONTINUE
10100     CONTINUE
10150     CONTINUE
      PRINT 11
      PRINT 110, TIME
      PRINT 100, ( DXX(I), DYY(I), DZZ(I), I=1,NJT )
      PRINT 90
      PRINT 120, TIME
      PRINT 100, ( VELJT(I), I = 1,NJTT )
      PRINT 90
      PRINT 130, TIME
      PRINT 100, ( ACCJT(I), I = 1,NJTT )
          IF (NSMJ .EQ. 0) GO TO 11000
          DO 10250 II = 1,NSMJ
                I = MJ(II)
                II3 = II*3
          DO 10200 J = 1,NTI1
          IF ( II .EQ. 1) GO TO 10190
          IF (MJO .EQ. 0) GO TO 10190
          IF (MJO .EQ. 1) GO TO 10180
                TR(J) = DISJT(II3-2,J) - DISJT(II3-5,J)
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          GO TO 10200
10180         TR(J) = DISJT(II3-2,J) -DISJT(1,J)
          GO TO 10200
10190         TR(J) = DISJT(II3-2,J)
10200     CONTINUE
      CALL CSPLOT (TR,1,I,TIME,II)
          DO 10300 J = 1,NTI1
          IF ( II .EQ. 1) GO TO 10290
          IF (MJO .EQ. 0) GO TO 10290
          IF (MJO .EQ. 1) GO TO 10280
              TR(J) = DISJT(II3-1,J) - DISJT(II3-4,J)
          GO TO 10300
10280         TR(J) = DISJT(II3-1,J) -DISJT(2,J)
          GO TO 10300
10290         TR(J) = DISJT(II3-1,J)
10300     CONTINUE
      CALL CSPLOT (TR,2,I,TIME,II)
          DO 10400 J = 1,NTI1
          IF ( II .EQ. 1) GO TO 10390
          IF (MJO .EQ. 0) GO TO 10390
          IF (MJO .EQ. 1) GO TO 10380
              TR(J) = DISJT(II3,J) - DISJT(II3-3,J)
          GO TO 10400
10380         TR(J) = DISJT(II3,J) -DISJT(3,J)
          GO TO 10400
10390         TR(J) = DISJT(II3,J)
10400     CONTINUE
      CALL CSPLOT (TR,3,I,TIME,II)
          IF ( APROB .NE. SAVE ) GO TO 10540
      WRITE (16,256) MJ(II)
              TEMP = TIME - ANTI1 * DTI
          DO 10530 J = 1,NTI1
              TEMP = TEMP + DTI
      WRITE (16,257) MJ(II),J,TEMP,DISJT(II3-2,J),DISJT(II3-1,J),
     2    DISJT(II3,J)
10530     CONTINUE
10540     CONTINUE
10250     CONTINUE
11000 CONTINUE
          IF ( IABAN .EQ. 1 ) NTR = NTR + 1
          IF ( IABAN .EQ. 0 ) GO TO 11100
          IF ( NTR .EQ. 0 .OR. NTR .GT. NTRA ) GO TO 11100
             DTI = DTI * 0.5
              TEMP = ( TOTTME - TIME ) / DTI
              NTI = TEMP
              ITYPE = 4
      PRINT 200
      GO TO 900
11100     CONTINUE
      RETURN
      END


********************************* SUBROUTINE *********************************
      SUBROUTINE JTCORD
COMMENT - SUBROUTINE JTCORD INPUTS JOINT GEOMETRY DATA (TABLE 2)
COMMENT - CHECKS FOR BAD DATA, COMPUTES JOINT COORDINATES,ECHO PRINTS
COMMENT - DATA AND PRINTS COMPUTED JOINT COORDINATES
      IMPLICIT REAL*8 (A-H,O-Z)
      DIMENSION J2( 7 )
      COMMON /BLOCK1/ X(25),       Y(25),       QXX(25),     QYY(25),
     2    QZZ(25),    SXX(25),     SYY(25),     SZZ(25),     DXX(25),
     3    DYY(25),    DZZ(25),     RXX(25),     RYY(25),     RZZ(25),
     4    ERXX(25),   ERYY(25),    ERZZ(25),    QMJ(25),     WMJ(25),
     5    NSXX(25),   NSYY(25),    NSZZ(25),    IMJ(25),     NSXP(25),
     6    NSYP(25),   ISTJR(25)
      COMMON /BLK1/  TOL,    ELEMNT,NJST,   KEEP3C,NCD3C,
     2        KEEP2, KEEP3A,KEEP3B,KEEP4A,KEEP4B,KEEP4C,KEEP5A,
     3        KEEP5B,KEEP5C,KEEP5D,KEEP6, KEEP7, NCD2,  NCD3A,
     4        NCD3B, NCD4A, NCD4B, NCD4C, NCD5A, NCD5B, NCD5C,
     5        NCD5D, NCD6,  NCD7,  IP8,   IP9,   IP10,  ITYPE,
     6        IABAN, IFORM, NM,    NJT,   NST,   NLT,   M,
     7        MP1,   MP2,   ISTT,  LTT,   ITYPEL,IDJ,   NSTL
      COMMON /BLK3/ MNJT,MNST,MNLT,MNM,MNC5,MNC6,MDJT,MNJS,MNE,MNCS,
     2    MNPCS,MNSS,MNOWM,MNJST,MNJSS
    9 FORMAT (        35H         TABLE 2 - FRAME GEOMETRY DATA ,///)
   10 FORMAT (10X,I5,5X,I5,5X,2E10.3,10X,E10.3)
   11 FORMAT (        32H         NUMBER OF JOINTS IN FRAME =,I5,/,
     2           30H      REFERENCE JOINT IS JOINT ,I5,     5H  AT ,
     3            5H X  =,E12.3,10H AND Y =   ,E10.3,/ ,3X,
     4           25H  JOINT TOLERANCE IS      ,E10.3,///)
   12 FORMAT (10X,I5,5X,2E10.3,5X,7I5)
   13 FORMAT ( 10X,I5,5X,2E11.3,5X,7I5)
   14 FORMAT ( 25X,   23H INPUT OF JOINT OFFSETS ,//,
     2         10X,   35H FROM          X-OFFSET    Y-OFFSET    ,3X,
     3                35H  TO    TC    TO    TO    TO    TO    TO ,/,
     4      10X,    5HJOINT, 32X, 5HJOINT ,/)
   15 FORMAT ( 47X,7I5)
   16 FORMAT ( 10X,I5)
   17 FORMAT     (48H        HOLDING DATA FROM THE PREVIOUS PROBLEM PLUS,
     2           15H THE FOLLCWING , //)
   18 FORMAT   ( 33H        NUMBER OF JOINTS IN FRAME =  , I5,///)
   19 FORMAT ( 3(/),10X,    26HCOMPUTED JOINT COORDINATES, //, 10X,
     2                      25HJOINT      X               Y    ,/)
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20 FORMAT (  45H      JOINT NUMBERS MUST BE POSITIVE             )
21 FORMAT ( 10X,I5,2E11.3)
22 FORMAT (   18H      JOINT NUMBERS, I5,12H NOT LOCATED )
23 FORMAT (   10H      NONE )
30 FORMAT (   40H      NO DATA HELD OR READ IN TABLE 2     )
31 FORMAT (   50H      NUMBER OF CARDS IN TABLE 2 MAY NOT EQUAL 1    )
50 FORMAT (   43H      JOINT NUMBER ABOVE GREATER THAN NUMBER,
    2         20H OF JOINTS IN FRAME )
60 FORMAT (   43H      NUMBER OF JOINTS IN FRAME GREATER THAN,
    2         15H STORAGE ALLOWS)
70 FORMAT (   35H             X AND Y OFFSETS FOR JOINT, I7,
    2         15H  ARE BOTH ZERO)
80 FORMAT (   10H      JOINT, I5,  30H  HAS NOT PREVIOUSLY BEEN SPEC,
    2         5HIFIED)
90 FORMAT (   32H      ERROR IN LOCATION OF JOINT , I5,
    2         40H  EXCEEDS THE TOLERANCE SPECIFIED ABOVE ,/,4X,
    3         30H THE ERROR IN X DIRECTION IS   ,E10.3,/,4X,
    4         30H THE ERROR IN Y DIRECTION IS  ,E10.3)
      PRINT 9
         IF (NCD2 .EQ. 1) GO TO 8100
         IF ( NCD2 .LE. 0 .AND.   KEEP2 .LE. 0 ) GO TO 8300
         IF(NCD2 .NE. 0) GO TO 1150
COMMENT - NO NEW DATA
      PRINT 17
      PRINT 23
         GO TO 9800
 1150    CONTINUE
            JNTL = 0
         IF (KEEP2 .EQ. 1) GO TO 1230
COMMENT - ALL NEW DATA - SET COORDINATES EQUAL TO 1.01E50
         DO 1200 I = 1,MNJT
            X(I) = 1.01E20
 1200       Y(I) = 1.01E20
COMMENT - READ FIRST CARD OF TABLE 2
      READ  10,NJT,J1,DX,DY,TCL
      PRINT 11,NJT,J1,DX,DY,TOL
         IF (J1 .LE. 0) GO TO 8200
COMMENT - COMPUTE COORDINATES OF REFERENCE JOINT
         IF (J1 .GT. NJT) GO TO 8500
            X(J1) = DX
            Y(J1) = DY
         GO TO 1240
COMMENT - HOLDING DATA
COMMENT - READ FIRST CARD OF TABLE 2
 1230 READ 16,NJT
      PRINT 17
      PRINT 18,NJT
 1240    CONTINUE
         IF (NJT .GT. MNJT) GO TC 8600
      PRINT 14
            N2M1 = NCD2 - 1
COMMENT - DO FOR SECOND AND SUCCEEDING CARDS OF TABLE 2
         DO 4900 JJ = 1,N2M1
      READ  12,J1,DX ,DY ,(J2(II),II=1,7)
         IF (J1 .GT. NJT)    JNTL = 1
            NJNZ = 0
         DO 1270 II = 1,7
         IF (J2(II) .GT. NJT) JNTL = 1
 1270    IF (J2(II) .NE. 0) NJNZ = NJNZ + 1
      PRINT 13,J1,DX ,DY ,(J2(II),II=1,NJNZ)
         IF (J1 .LE. 0  .OR. J2(1) .LE. 0)  GO TO 8200
COMMENT - CHECK IF FROM JCINT HAS BEEN LOCATED
 1300    IF (X(J1) .GT. 1.0E20) GO TC 8800
         IF ( DX  .EQ. 0.0 .AND. DY  .EQ. 0.0 ) GO TO 8700
         IF (JNTL .EQ. 1) GO TO 8500
COMMENT - DO FOR ALL JOINTS SPECIFIED CN THIS CARD
         DO 4600 II= 1,NJNZ
COMMENT - COMPUTE TEMPORARY VALUES OF COORDINATES
 3250       XT = X(J1) + DX
            YT = Y(J1) + DY
            J2II = J2(II)
         IF (J2II .LE. 0) GC TO 8200
         IF (X(J2II)  .GT. 1.00E20) GO TO 4000
COMMENT - JOINT PREVIOUSLY LOCATED COMPUTE DIFFERENCE BETWEEN OLD
COMMENT - LOCATION AND NEW LOCATICN ERX AND ERY
            ERX =      (X(J2II)  - XT)
            ERY =      (Y(J2II)  - YT)
         IF (ERX .LT. 0.0 ) ERX = -ERX
         IF (ERY .LT. 0.0 ) ERY = -ERY
         IF ( ERX .GT. TOL .OR. ERY .GT. TCL) GO TO 8900
COMMENT - AVERAGE OLD AND NEW COORDINATES
            X(J2II)  = 0.5*(X(J2II)  + XT)
            Y(J2II)  = 0.5*(Y(J2II)  + YT)
         GO TO 4500
COMMENT - JOINT NOT PREVIOUSLY LOCATED
 4000       X(J2II)  = XT
            Y(J2II)  = YT
 4500    CONTINUE
            J1 = J2II
 4600    CONTINUE
 4900    CONTINUE
         GC TO 9800
 8100 PRINT 31
         GO TO 9700
 8200 PRINT 20
         GC TO 9700
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8300 PRINT 30
          GO TO 9700
8500 PRINT 50
          GO TO 9700
8600 PRINT 60
          GO TO 9700
8700 PRINT 70, J1
          GO TO 9700
8800 PRINT 80,J1
          GO TO 9700
8900 PRINT 90, J2II,ERX,ERY
9700           IABAN = 1
          GO TO 9900
9800      CONTINUE
     PRINT 19
COMMENT - PRINT JOINT COORDINATES AND CHECK FOR JOINT NOT SPECIFIED
          DO 9850  I = 1,NJT
          IF  (X(I)  .GT.  1.0E20 .OR. Y(I) .GT. 1.0E20) GO TO 9840
9830 PRINT 21,I,X(I),Y(I)
          GO TO 9845
9840 PRINT 22,I
               IABAN = 1
9845      CONTINUE
9850      CONTINUE
9900      CONTINUE
     RETURN
     END


*********************************** SUBROUTINE ***********************************
      SUBROUTINE MEMLOC
COMMENT - SUBROUTINE MEMLCC INPUTS LOCATION OF MEMBER STIFFNESS AND LOAD
COMMENT - TYPES IN FRAME, AND JOINT DATA AND JOINT SHEAR STRESS-STRAIN
COMMENT - CURVES FOR ANALYSIS THAT INCLUDES JCINT SHEAR DEFORMATION
COMMENT - EFFECTS (TABLE 3). ALSO COMPUTES MEMBER NUMBERS, LENGTHS, ETC.
      IMPLICIT REAL*8 (A-H,O-Z)
      REAL*8 JTSHR,JSYES
      DIMENSION J2(10),JOINT(14)
      COMMON /BLOCK1/ X(25),        Y(25),      QXX(25),     QYY(25),
     2   QZZ(25),      SXX(25),     SYY(25),    SZZ(25),     DXX(25),
     3   DYY(25),      DZZ(25),     RXX(25),    RYY(25),     RZZ(25),
     4   ERXX(25),     ERYY(25),    ERZZ(25),   QMJ(25),     WMJ(25),
     5   NSXX(25),     NSYY(25),    NSZZ(25),   IMJ(25),     NSXP(25),
     6   NSYP(25),     ISTJR(25)
      COMMON /BLOCK2/ DXS( 25),     DYS( 25),   ZLS( 25),    DC1S( 25),
     2   DC2S( 25),    PRF( 25),    PRAE( 25),  QM( 25),     WM( 25),
     3   PRAG(25),     ELEMN(25),
     4   IOPOP( 25),   IPINL( 25),  IPINR( 25), NC51( 25),   INLOP( 25),
     5   NAL( 25),     NSXL( 25),   NSYL( 25),  NSZL( 25),   NAR( 25),
     6   NSXR( 25),    NSYR( 25),   NSZR( 25),  NCDS( 25),   IAXOPS( 25)
      COMMON /BALA02/ JST(25),NJSS(25),HLJ(25),HRJ(25),VLJ(25),VUJ(25),
     2   THKJ(25),GJ(25),SJC(25)
      COMMON /BLOCK3/ DXL( 25),     DYL( 25),   ZLL( 25),    DC1L( 25),
     2   DC2L( 25),    UQX( 25),    UQY( 25),   NCDL( 25),   IAXOPL( 25),
     3   NC61( 25),    IOVRM(25)
      COMMON /BLOCK4/ FOMM(50,6),SMC(50,21),IST(50),     LT(50),
     2   JT1(50),      JT2(50),       NITM(50),    IMM(50),    IMC(50)
      COMMON /BLK1/  TOL,    ELEMNT,NJST,   KEEP3C,NCD3C,
     2          KEEP2, KEEP3A,KEEP3B,KEEP4A,KEEP4B,KEEP4C,KEEP5A,
     3          KEEP5B,KEEP5C,KEEP5D,KEEP6, KEEP7, NCD2,  NCD3A,
     4          NCD3B, NCD4A, NCD4B, NCD4C, NCD5A, NCD5B, NCD5C,
     5          NCD5D, NCD6,  NCD7,  IP8,   IP9,   IP10,  ITYPE,
     6          IABAN, IFORM, NM,    NJT,   NST,   NLT,   M,
     7          MP1,   MP2,   ISTT,  LTT,   ITYPEL,IDJ,   NSTL
      COMMON /BLK3/ MNJT,MNST,MNLT,MNM,MNC5,MNC6,MDJT,MNJS,MNE,MNCS,
     2   MNPCS,MNSS,MNQWM,MNJST,MNJSS
      COMMON /SKT11/       MSSINL,          MSSIM1
      COMMON /CHAN1/ JTSHR
      COMMON /CHAN13/ NPTJ( 08),   JSS( 08),  NTAU(08,08),NGAM(08,08),
     2   NTAT(08),      NGAT(08),TAUMLT(08),GAMMLT(08)
      COMMON /CHA31/ ALPHJ (8), BETJ   (8), SMLSLJ(8), GASTHD(8),
     2               SLPHDJ(8), TAUULT(8), MATRJ  (8)
    6 FORMAT (5X,  3(I5,1X), 2X, 2I5)
    7 FORMAT (5X,  3(I5,1X), 2X, 2I5, 3E11.3)
    8 FORMAT  (///,10X,     40H COMPUTED MEMBER NUMBERS,LENGTHS,AND OFF,
     2 4HSETS,//,46H     MEMBER  FROM   TO    STIFF LOAD   LENGTH   ,
     3             25H  X-OFFSET   Y-OFFSET    ,/,
     4             35H      NUMB  JOINT  JOINT   TYPE TYPE,//)
    9 FORMAT (//,40H      TABLE 3C - MEMBER LOCATION DATA       ,///)
   10 FORMAT ( 10X, I5, 5X, I5 )
   11 FORMAT  (  40H      NUMBER OF MEMBER STIFFNESS TYPES  =,I5,/,
     2   5X, 35HNUMBER OF MEMBER LOAD TYPES        =,I5,///)
   12 FORMAT ( 5X,I5,5X,2I5,5X,10I5)
   13 FORMAT ( 5X,I5,5X,2I5,5X,10I5)
   14 FORMAT (25X,     26H INPUT OF MEMBER LOCATIONS ,//,
     2             50H      FROM      STIFF LOAD        TO    TO    TO    TO ,
     3             30H  TO    TO    TO    TO    TO    TO ,/,
     4             35H      JOINT        TYPE TYPE      JOINT,//)
   17 FORMAT      (48H      HOLDING DATA FROM THE PREVICUS PROBLEM PLUS,
     2             15H THE FOLLOWING ,//)
   18 FORMAT (//,47H *** COMPUTED MEMBER NUMBERS MAY NOT AGREE WITH ,
     2             20H LAST PROBLEM ***     )
   19 FORMAT (//,50H *** COMPUTED MEMBER NUMBERS AGREE WITH LAST PROBL,
     2             10HEM ***     )
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   20 FORMAT (     45H      JOINT NUMBERS MUST BE POSITIVE            )
   23 FORMAT (     10H      NONE )
   25 FORMAT (     32H      MEMBER WITH STIFFNESS TYPE ,I5, 9H AND LOAD,
     2              5H TYPE,I5,/,32H      WAS SPECIFIED AS GOING FROM,
     3              7H JOINT ,I5, 9H TO JOINT,I5,/,17H      PROGRAM DOES,
     4             36H NOT ALLOW THIS ORDER TO BE REVERSED)
   30 FORMAT (     40H      NO DATA HELD OR READ IN TABLE 3C      )
   31 FORMAT (     50H      NUMBER OF CARDS IN TABLE 3C MAY NOT EQUAL 1    )
   50 FORMAT (     43H      JOINT NUMBER ABOVE GREATER THAN NUMBER,
     2             20H OF JOINTS IN FRAME )
   61 FORMAT (     51H      NUMBER OF STIFFNESS TYPES GREATER THAN STORAGE,
     2              7H ALLOWS)
   62 FORMAT (     46H      NUMBER OF LOAD TYPES GREATER THAN STORAGE,
     2              7H ALLOWS)
   71 FORMAT (     46H      STIFFNESS AND LOAD TYPES MUST BE POSITIVE,
     2              8H NUMBERS)
   72 FORMAT (     51H     STIFFNESS OR LOAD TYPE ABOVE GREATER THAN TOTAL,
     2             50H NUMBER OF STIFFNESS OR LOAD TYPES SPECIFIED ABOVE)
   73 FORMAT (     51H      YOU CANNCT HOLD UP THE LOAD WITHOUT SOME STIFF,
     2             50HNESS - IF STIFF TYPE = 0 - LOAD TYPE MUST = 0      )
   74 FORMAT (     45H      MAXIMUM BAND WIDTH OF EQUATIONS EXCEEDED, /,
     2             45H      RENUMBER JOINTS OR REDIMENSION DRIVER     )
   91 FORMAT (     50H      ERROR IN OFFSETS FOR MEMBER OF STIFFNESS TYPE,
     2        I5,/,47H      THE X AND Y OFFSETS FOR THE MEMBER BETWEEN,
     3              7H JOINTS,I5, 5H AND ,I5,/,
     4             49H      DO NOT AGREE WITH PREVIOUSLY DEFINED OFFSETS,
     5             46H FOR A MEMBER OF THIS TYPE, WITHIN THE ALLOWED,/,
     6             51H      ERROR OF TWO TIMES THE JOINT LOCATICN TOLERANC,
     7              1HE)
   92 FORMAT (     45H      ERROR IN OFFSETS FOR MEMBER OF LOAD TYPE,
     2        I5,/,47H      THE X AND Y OFFSETS FOR THE MEMBER BETWEEN,
     3              7H JOINTS,I5, 5H AND ,I5,/,
     4             49H      DO NOT AGREE WITH PREVIOUSLY DEFINED OFFSETS,
     5             46H FOR A MEMBER OF THIS TYPE, WITHIN THE ALLOWED,/,
     6             51H      ERROR OF TWO TIMES THE JOINT LOCATION TOLERANC,
     7              1HE)
   93 FORMAT (     51H      NUMBER CF JOINT STIFFNESS TYPES MUST BE POSITI,
     2             50HVE AND LESS THAN OR EQUAL TO THE ALLOWABLE STORAGE)
   94 FORMAT (     51H      JOINT STIFFNESS TYPE MUST BE POSITIVE AND LESS,
     2             49H THAN OR EQUAL TO THE NUMBER OF JOINT STIFF TYPES)
   95 FORMAT (     46H      ALL THE JOINT STIFF.TYPES ARE NCT DEFINED)
   96 FORMAT (     50H      ORIENTATION OF A HORIZONTAL MEMBER HAS TO BE ,
     2             48HIN THE POSITIVE X-DIRECTION FOR THE JSYES OPTION)
   97 FORMAT (     50H      ORIENTATION OF A VERTICAL MEMBER HAS TO BE IN,
     2             46H THE POSITIVE Y-DIRECTION FOR THE JSYES OPTION)
   98 FORMAT (     51H      CNLY RECTANGULAR FRAMES CAN BE ANALYZED IN THE,
     2             13H JSYES OPTION)
   99 FORMAT (     46H      ERROR IN THE MEMBER WITH STIFFNESS TYPE =, I5,
     2             16H AND LOAD TYPE =, I5,20H THAT CONNECTS JOINT, I5,
     3              9H TO JOINT, I5)
  100 FORMAT (     40H      TABLE 3A - JOINT TYPE AND SIZE DATA,///)
  101 FORMAT (     12H      NO DATA,/)
  110 FORMAT (I5,5X,14I5)
  111 FORMAT (     38H      NUMBER OF JOINT STIFFNESS TYPES =,I5,/)
  112 FORMAT (     21H      JOINT       JOINTS,/,9H       TYPE,/)
  113 FORMAT (5X,I5,5X,14I5)
  114 FORMAT (I5,5X,6E10.3,I5)
  115 FORMAT (//,49H      JOINT STIFF      HLJ          HRJ          VLJ     ,
     2             40H      VUJ          THKJ          GJ          NJSS ,/,
     3              9H      TYPE,/)
  116 FORMAT (5X,I5,5X,6E11.3,I5)
  120 FORMAT (//,48H      TABLE 3B - JCINT SHEAR STRESS STRAIN CURVES,//)
  121 FORMAT (     45H      MATE CURVE NUMB SYMT (1=YES,      TAU-MULT,
     2             11H      GAM-MULT,/,
     3             34H      RIAL NUMB   PTS    OPT     0 = NO) )
  122 FORMAT ( 1X,A4, 3I5, 2E10.3, 8I5,/, 2E10.3,20X, 8I5 )
  123 FORMAT (/,8X,2H- ,3(I3,2X),10X,2E11.3,//,6X,3HTAU,17X,8I5)
  124 FORMAT (/6X,A4,3(I3,2X),10X,2E11.3,//,6X,3HTAU,17X,8I5)
  125 FORMAT (/,6X,3HGAM,17X,8I5)
  150 FORMAT (     48H      EITHER SHEAR MODULUS OR SHEAR STRESS-STRAIN,
     2             33H CURVE NUMBER SHOULD BE SPECIFIED )
  151 FORMAT (     47H      BOTH SHEAR MODULUS AND SHEAR STRESS-STRAIN,
     2             45H CURVE NUMBER CANNOT BE SPECIFIED FOR A JOINT,
     3             15H STIFFNESS TYPE )
  152 FORMAT (     50H      JOINT SHEAR STRESS-STRAIN CURVE NUMBER SHOULD,
     2             48H BE POSITIVE AND LESS THAN THE MAXIMUM ALLOWABLE,
     3             33H JOINT STRESS-STRAIN CURVE NUMBER )
  153 FORMAT (     49H      NO CARDS SHALL BE SPECIFIED IN TABLE 3B WHEN,
     2             41H JOINT SHEAR OPTION IS NOT EQUAL TO JSYES )
  154 FORMAT (     49H      IF KEEP3B IS NOT EQUAL TO 1, NCD3B HAS TO BE,
     2              9H NON-ZERO )
  155 FORMAT (     47H      NUMBER OF CARDS IN THIS TABLE MUST BE EVEN)
  156 FORMAT (     47H      IF SYMMETRY OPTION=1, FIRST PCINT ON CURVE,
     2             23H MUST BE EQUAL TO (0,0) )
  157 FORMAT (     40H      SYMMETRY OPTION MUST BE 1 OR 0        )
  158 FORMAT (     48H      NUMBER OF POINTS ON CURVE MUST BE BETWEEN 2,
     2              7H AND  8)
  159 FORMAT (     50H      TOO LARGE A NUMBER FOR STRESS-STRAIN CURVE NU,
     2             35HMBER OR NO CURVE NUMBER SPECIFIED  )
  160 FORMAT (     31H      STRESS-STRAIN CURVE NUMBER,I5,  10H NOT INPUT)
  161 FORMAT (     50H      NO DATA SHALL BE INPUT IN TABLE 3B WHEN NO SH,
     2             51HEAR STRESS-STRAIN CURVE IS SPECIFIED FOR THE JOINTS)
      DATA JSYES /5HJSYES/
      DATA MTNO /4H    /
COMMENT - INPUT TABLE 3A
      PRINT 100
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      IF (JTSHR.EQ.JSYES) GO TO 210
      PRINT 101
      GO TO 510
COMMENT - SET ALL THE JOINT STIFFNESS TYPES TO ZERO
  210 CONTINUE
      IF (KEEP3A .NE. 1) GO TC 215
      PRINT 17
      IF (NCD3A .NE. 0) GO TO 215
      PRINT 23
      GO TO 510
  215 JNTL = 0
      DO 220 J = 1,NJT
  220 JST(J) = -1
      READ  110,NJST
      PRINT 111,NJST
      IF(NJST.LE.0.OR.NJST.GT.MNJST) GO TO 8930
COMMENT - READ JOINTS WITH THE SAME TYPE NUMBER.
      PRINT 112
      NTEMP = NCD3A-NJST-1
      DO 400 J = 1,NTEMP
      READ 110,JSTT,(JOINT(II),II=1,14)
      NJNZ=0
      DO 250 II = 1,14
      IF (JOINT(II).GT.NJT) JNTL=1
      IF (JOINT(II).NE.0) NJNZ = NJNZ + 1
  250 CONTINUE
COMMENT - PRINT JOINTS WITH THE SAME STIFFNESS TYPE NUMBER
      PRINT 113,JSTT,(JOINT(II),II=1,NJNZ)
      IF (JNTL.EQ.1) GO TC 8500
      IF (JSTT.LT.0.OR.JSTT.GT.NJST) GO TO 8940
COMMENT - ASSIGN JOINT STIFFNESS TYPE NUMBER FOR THE JOINTS SPECIFIED
COMMENT - ON ONE CARD
      DO 300 K = 1,NJNZ
      KTEMP = JOINT(K)
      JST(KTEMP) = JSTT
  300 CONTINUE
  400 CONTINUE
COMMENT - CHECK WHETHER ALL THE JOINT STIFFNESS TYPES ARE DEFINED
      DO 410 J = 1,NJT
      IF (JST(J).EQ.-1) GO TO 8950
  410 CONTINUE
      PRINT 115
      DO 500 J = 1,NJST
      READ  114,JSTT,HLJT,HRJT,VLJT,VUJT,THKJT,GJT,NC
      PRINT 116,JSTT,HLJT,HRJT,VLJT,VUJT,THKJT,GJT,NC
      IF (JSTT .EQ. 0) GO TO 500
      HLJ(JSTT) = HLJT
      HRJ(JSTT) = HRJT
      VLJ(JSTT) = VLJT
      VUJ(JSTT) = VUJT
      THKJ(JSTT) = THKJT
      GJ(JSTT) = GJT
      NJSS(JSTT) = NC
COMMENT - COMPUTE THE JOINT CONSTANT THAT IS USED TO CALCULATE JOINT
COMMENT - SHEAR MOMENT AND JOINT STIFFNESS.
      SJC(JSTT) = THKJT*(HLJT+HRJT)*(VLJT+VUJT)
      IF (GJT .EQ. 0 .AND. NC .EQ. 0) GO TO 9150
      IF (GJT .NE. 0 .AND. NC .NE. 0) GO TO 9151
      IF (NC .LT. 0 .OR. NC .GT. MNJSS) GO TO 9152
  500 CONTINUE
COMMENT - INPUT TABLE 3B
  510 PRINT 120
      IF (JTSHR .EQ. JSYES) GO TO 520
      IF (NCD3B .NE. 0) GO TO 9153
      PRINT 101
      GO TO 1090
  520 CONTINUE
      NTEMP = 0
      DO 521 J = 1,NJT
      JSTT = JST(J)
      NTEMP = NTEMP + NJSS(JSTT)
  521 CONTINUE
      IF (NTEMP .NE. 0) GO TO 522
      IF (NCD3B .NE. 0) GO TO 9161
      PRINT 101
      GO TO 1090
  522 CONTINUE
      IF (KEEP3B .NE. 1) GO TC 525
      PRINT 17
      IF (NCD3B .NE. 0) GO TO 525
      PRINT 23
      GO TO 1090
  525 CONTINUE
      IF (KEEP3B .NE.1 .AND. NCD3B .EQ. 0) GO TO 9154
      IF (KEEP3B .EQ. 1) GO TO 535
      DO 530 I=1,MNJSS
      NPTJ(I) = -1
  530 CONTINUE
  535 NCD3B2 = NCD3B/2
      IF (NCD3B2*2 .NE. NCD3B) GO TO 9155
COMMENT - INPUT SHEAR STRESS-STRAIN CURVE ON TWO CARDS
      DO 560 II = 1,NCD3B2
      PRINT 121
      READ 122,MTRL,NC,NPTT,ISJT,ALPH,BET,(NTAT(I),I=1,8),
     2 TAUMT,GAMMT,(NGAT(I),I=1,8)
      IF (MTRL .NE. MINO) GO TO 540
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      PRINT 123,NC,NPTT,ISJT,TAUMT,GAMMT,(NTAT(I),I=1,NPTT)
         GO TO 541
  540    CONTINUE
      PRINT 124,MTRL,NC,NPTT,ISJT,TAUMT,GAMMT,(NTAT(I),I=1,NPTT)
  541    CONTINUE
      PRINT 125,                     (NGAT(I),I=1,NPTT)
         IF (ISJT .EQ. 1 .AND. NTAT(1) .NE. 0) GO TO 9156
         IF (ISJT .EQ. 1 .AND. NGAT(1) .NE. 0) GO TO 9156
         IF (ISJT .NE. 1 .AND. ISJT .NE. 0) GO TO 9157
         IF (NPTT .LT. 2 .OR. NPTT .GT.  8) GO TO 9158
         IF (NC .LT.0 .OR. NC .GT. MNJSS) GO TO 9159
         DO 545 I = 1,NPTT
               NTAU(NC,I) = NTAT(I)
               NGAM(NC,I) = NGAT(I)
  545    CONTINUE
               NPTJ(NC) = NPTT
               JSS(NC) = ISJT
               MATRJ(NC) = MTRL
               ALPHJ(NC) = ALPH
               BETJ(NC) = BET
               TAUMLT(NC) = TAUMT
               GAMMLT(NC) = GAMMT
COMMENT - SUBROUTINE  TGCUR() DEALS WITH SHEAR STRESS-STRAIN CURVE NO.
COMMENT - NC AND ITS SUBDIVISIONING FOR PURPOSES OF INELASTIC TREATMENT
COMMENT - FOR THE PRESENT INELASTIC CASE IS RESTRICTED TO SYMMETRIC
COMMENT - CURVES WITH NUMBER OF INPUT POINTS (OF THE SYMMETRY PART)
COMMENT - LESS THAN OR EQUAL TO  MSSINL ( = 4 AT PRESENT ) INCLUDING
COMMENT - ORIGIN (0,0)
COMMENT - SUBROUTINE TGCUR ALSO DETERMINES THE IMPORTANT INFORMATIONS
COMMENT - FROM THE SPECIAL INPUT CURVE FOR MILD STEEL ( WITH VIRGIN
COMMENT - STRAIN HARDENING )
         IF (ISJT .EQ. 1 .AND. NPTT .LE. MSSINL ) GO TO 550
      GO TO 560
  550 CALL        TGCUR ( NC, IABAN )
  560    CONTINUE
COMMENT - CHECK FOR UNDEFINED SHEAR STRESS-STRAIN CURVE NUMBER
         DO 570 I = 1,NJT
               JSTT = JST(I)
         IF (JSTT .EQ. 0) GO TO 570
         IF (NJSS(JSTT) .EQ. 0) GO TO 570
               NC = NJSS(JSTT)
         IF (NPTJ(NC) .EQ. -1) GO TO 9160
  570    CONTINUE
COMMENT - INPUT TABLE 3C
 1090 PRINT 9
         IF (NCD3C .EQ. 1) GO TO 8100
         IF (NCD3C .LE. 0  .AND. KEEP3C .LE. 0 ) GO TO 8300
               TTOL = 2.0*TOL
COMMENT - SET OFFSETS FOR STIFF TYPES
         DO 1100  I = 1, MNST
               DXS(I) = 1.01E20
 1100          DYS(I) = 1.01E20
COMMENT - SET OFFSETS FOR LOAD TYPES
         DO 1110  I = 1, MNLT
               DXL(I) = 1.01E20
 1110          DYL(I) = 1.01E20
         IF (KEEP3C .NE. 1) GO TO 1150
      PRINT 17
         GO TO 1160
 1150          NM = 0
 1160    CONTINUE
         IF (NCD3C .NE. 0) GO TO 1180
      PRINT 23
         GO TO  6000
 1180          JNTL = 0
 1250    CONTINUE
COMMENT - READ FIRST CARD IN TABLE 3C
      READ 10, NST, NLT
      PRINT 11, NST, NLT
         IF (NST .GT. MNST) GO TO 8610
         IF (NLT .GT. MNLT) GO TO 8620
      PRINT 14
               N3CM1 = NCD3C - 1
         DO 4900 JJ = 1,N3CM1
COMMENT - READ 2ND AND SUCCEEDING CARDS IN TABLE 3C
      READ 12,J1,ISTT,LTT,(J2(II),II = 1,10)
         IF (J1 .GT. NJT) JNTL = 1
               NJNZ = 0
         DO 1270 II = 1,10
         IF (J2(II) .GT. NJT) JNTL = 1
         IF (J2(II) .NE. 0) NJNZ = NJNZ + 1
 1270    CONTINUE
COMMENT - PRINT 2ND AND SUCCEEDING CARDS IN TABLE 3C
      PRINT 13,J1,ISTT,LTT, (J2(II),II = 1,NJNZ )
         IF (J1 .LE. 0) GO TO 8200
         IF (JNTL .EQ. 1)  GO TO 8500
      IF (ISTT .LT. 0 .OR. LTT .LT. 0) GO TO 8710
      IF (ISTT .GT. NST .OR. LTT .GT. NLT) GO TO 8720
         IF (ISTT .EQ. 0 .AND. LTT .NE. 0) GO TO 8730
COMMENT - NUMBER MEMBERS AND ASSIGN STIFFNESS AND LOAD TYPES
COMMENT - DO FOR NUMBER OF MEMBERS SPECIFIED ON ONE CARD
         DO 4500  II = 1,NJNZ
               J2II = J2(II)
         IF (J2II .LE. 0) GO TO 8200
         IF (KEEP3C .NE. 1) GO TO 4425
COMMENT - DO FOR EACH MEMBER
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      DO 4400 K = 1,NM
      IF (J1 .EQ. JT1(K) .AND. J2II .EQ. JT2(K) ) GO TO 4410
      IF (J1 .EQ. JT2(K) .AND. J2II .EQ. JT1(K) ) GO TO 8250
 4400 CONTINUE
      GO TO 4425
COMMENT - OLD MEMBER (PREVIOUSLY GIVEN STIFF AND LOAD TYPE)
 4410 IST(K) = ISTT
      LT(K) = LTT
      GO TO 4450
COMMENT - NEW MEMBER INCREASE NM
 4425       NM = NM + 1
            JT1(NM) = J1
            JT2(NM) = J2II
            IST(NM) = ISTT
            LT(NM) = LTT
 4450 CONTINUE
            J1 = J2II
 4500 CONTINUE
 4900 CONTINUE
 6000 CONTINUE
      DO 6600  I = 1,NM
            ISTT = IST(I)
            LTT  =  LT(I)
            J2I  = JT2(I)
            J1   = JT1(I)
COMMENT - COMPUTE OFFSETS
            DX   = X(J2I)   - X(J1)
            DY   = Y(J2I)   - Y(J1)
      IF (JTSHR.NE.JSYES) GO TO 6010
      IF (DX .LT. 0.0) GO TO 8960
      IF (DY .LT. 0.0) GO TO 8970
      IF (DX .GT. 0.0 .AND. DY .GT. 0.0) GO TO 8980
            JST2 = JST(J2I)
      IF (JST2 .NE. 0) GO TO 6005
            HLJ2 = 0.0
            VLJ2 = 0.0
      GO TO 6006
 6005       HLJ2 = HLJ(JST2)
            VLJ2 = VLJ(JST2)
 6006       JST1 = JST(J1)
      IF (JST1 .NE. 0) GO TO 6007
            HRJ1 = 0.0
            VUJ1 = 0.0
      GO TO 6008
 6007       HRJ1 = HRJ(JST1)
            VUJ1 = VUJ(JST1)
 6008 CONTINUE
      IF (DX .GT. 0.0) DX=DX-HRJ1-HLJ2
      IF (DY .GT. 0.0) DY=DY-VUJ1-VLJ2
 6010 CONTINUE
      IF (ISTT .EQ. 0) GO TO 6100
      IF (DXS(ISTT) .GT. 1.0E20) GO TO 6050
COMMENT - CHECK FOR TWO MEMBERS WITH SAME STIFFNESS TYPE BUT DIFFERENT
COMMENT - ORIENTATIONS
            ERX =     (DXS(ISTT) - DX )
            ERY =     (DYS(ISTT) - DY )
      IF (ERX .LT. 0.0 ) ERX = -ERX
      IF (ERY .LT. 0.0 ) ERY = -ERY
      IF (ERX  .GT. TTOL .OR.  ERY  .GT. TTOL) GO TO 8910
            DXS(ISTT)  = 0.5*(DXS(ISTT) + DX)
            DYS(ISTT)  = 0.5*(DYS(ISTT) + DY)
      GO TO 6100
 6050 CONTINUE
            DXS(ISTT)  = DX
            DYS(ISTT)  = DY
 6100 CONTINUE
      IF ( LTT .EQ. 0) GO TO 6300
      IF (DXL(LTT) .GT. 1.0E20) GO TO 6200
COMMENT - CHECK FOR TWO MEMBERS WITH SAME LOAD TYPE BUT DIFFERENT
COMMENT - ORIENTATIONS
            ERX =     (DXL(LTT) - DX)
            ERY =     (DYL(LTT) - DY)
      IF (ERX .LT. 0.0 ) ERX = -ERX
      IF (ERY .LT. 0.0 ) ERY = -ERY
      IF (ERX .GT. TTOL .OR. ERY .GT. TTOL) GO TO 8920
            DXL(LTT) = 0.5*(DXL(LTT) + DX)
            DYL(LTT) = 0.5*(DYL(LTT) + DY)
      GO TO 6300
 6200 CONTINUE
            DXL(LTT) = DX
            DYL(LTT) = DY
 6300 CONTINUE
 6600 CONTINUE
      DO 7400 I = 1,NST
COMMENT - COMPUTE LENGTHS AND DIRECTION COSINES FOR STIFFNESS TYPES
            ZLS(I) = (DXS(I)*DXS(I) + DYS(I)*DYS(I) ) **0.5
            DC1S(I) = DXS(I)/ZLS(I)
 7400       DC2S(I) = DYS(I)/ZLS(I)
      IF (NLT.EQ.0)  GO TO 7600
      DO 7500 I = 1,NLT
COMMENT - COMPUTE LENGTHS AND DIRECTION COSINES FOR LOAD TYPES
            ZLL(I) = (DXL(I)*DXL(I) + DYL(I)*DYL(I) )**0.5
            DC1L(I) = DXL(I)/ZLL(I)
 7500       DC2L(I) = DYL(I)/ZLL(I)
 7600 CONTINUE
            IDJT = 0
```

```
              IDJ  = 0
COMMENT - COMPUTE HALF BAND WIDTH OF FRAME
          DO 7700 I = 1,NM
              IDJT = IABS (JT1(I) - JT2(I))
          IF (IDJT .GT. IDJ)   IDJ = IDJT
 7700     CONTINUE
          IF (IDJ .GT. MDJT)  GO TO 8740
              GO TO 9800
 8100 PRINT 31
              GO TO 9700
 8200 PRINT 20
              GO TO 9700
 8250 PRINT 25, ISTT,J2II,J1
              GO TO 9700
 8300 PRINT 30
              GO TO 9700
 8500 PRINT 50
              GO TO 9700
 8610 PRINT 61
              GO TO 9700
 8620 PRINT 62
              GO TO 9700
 8710 PRINT 71
              GO TO 9700
 8720 PRINT 72
              GO TO 9700
 8730 PRINT 73
              GO TO 9700
 8740 PRINT 74
              GO TO 9700
 8910 PRINT 91,ISTT,J1,J2I
              GO TO 9700
 8920 PRINT 92,LTT, J1,J2I
              GO TO 9700
 8930 PRINT 93
              GO TO 9700
 8940 PRINT 94
              GO TO 9700
 8950 PRINT 95
              GO TO 9700
 8960 PRINT 96
      PRINT 99,ISTT,LTT,J1,J2I
              GO TO 9700
 8970 PRINT 97
      PRINT 99,ISTT,LTT,J1,J2I
              GO TO 9700
 8980 PRINT 98
      PRINT 99,ISTT,LTT,J1,J2I
              GO TO 9700
 9150 PRINT 150
              GO TO 9700
 9151 PRINT 151
              GO TO 9700
 9152 PRINT 152
              GO TO 9700
 9153 PRINT 153
              GO TO 9700
 9154 PRINT 154
              GO TO 9700
 9155 PRINT 155
              GO TO 9700
 9156 PRINT 156
              GO TO 9700
 9157 PRINT 157
              GO TO 9700
 9158 PRINT 158
              GO TO 9700
 9159 PRINT 159
              GO TO 9700
 9160 PRINT 160,NC
              GO TO 9700
 9161 PRINT 161
 9700 IABAN = 1
              GO TO 9900
 9800         CONTINUE
      PRINT 8
COMMENT - PRINT MEMBER NUMBERS,FROM AND TO JOINTS,LENGTHS AND OFFSETS
          DO 9875 I = 1,NM
              ISTT = IST(I)
      IF (ISTT .EQ. 0) GO TO 9860
      PRINT 7, I, JT1(I), JT2(I), IST(I), LT(I), ZLS(ISTT), DXS(ISTT),
     2    DYS(ISTT)
          GO TO 9875
 9860 PRINT 6, I, JT1(I), JT2(I), IST(I), LT(I)
 9875     CONTINUE
          IF (KEEP3C .EQ. 1 ) GO TO 9880
      PRINT 18
          GO TO 9900
 9880 PRINT 19
 9900     CONTINUE
      RETURN
      END
```

```
************************************ SUBROUTINE ************************************
      SUBROUTINE JNTDAT
COMMENT - SUBROUTINE JNTDAT INPUTS JOINT LOADS AND RESTRAINTS
COMMENT - (TABLE 4),CHECKS FOR BAD DATA,ACCUMULATES JOINT LOADS AND
COMMENT - RESTRAINTS,ECHO PRINTS DATA AND PRINTS ACCUMULATED DATA
COMMENT - EQUILIBRIUM ERRORS ARE SET EQUAL TO NET JOINT LOADS
      IMPLICIT REAL*8 (A-H,O-Z)
      COMMON /DBLK1/KEEP4L,NCD4D,KEEP4E,NCD4E
      COMMON /DBLK3/ MNTVJL
      COMMON /BLOCK1/ X(25),         Y(25),       QXX(25),      QYY(25),
     2     QZZ(25),      SXX(25),      SYY(25),     SZZ(25),      DXX(25),
     3     DYY(25),      DZZ(25),      RXX(25),     RYY(25),      RZZ(25),
     4     ERXX(25),     ERYY(25),     ERZZ(25),    QMJ(25),      WMJ(25),
     5     NSXX(25),     NSYY(25),     NSZZ(25),    IMJ(25),      NSXP(25),
     6     NSYP(25),     ISTJR(25)
      COMMON /BALA01/ QVV(25),       SVV(25),     DVV(25),      ERVV(25),
     2     RVV(25),      NSVV(25)
      COMMON /BLOC1/ ZMASS(25),FTMJXX(25),FTMJYY(25),FTMJZZ(25),
     2     FTMJVV(25),TTMJ(25),NFTXX(25),NFTYY(25),NFTZZ(25),NFTVV(25)
      COMMON /BLOCK8/ NPT( 20),    ISJ( 20),    NQJ( 20,11),NWJ( 20,11),
     2     NQJT(11),     NWJT(11)
      COMMON /BLK1/  TOL,     ELEMNT,NJST,   KEEP3C,NCD3C,
     2          KEEP2, KEEP3A,KEEP3B,KEEP4A,KEEP4B,KEEP4C,KEEP5A,
     3          KEEP5B,KEEP5C,KEEP5D,KEEP6,  KEEP7,  NCD2,   NCD3A,
     4          NCD3B, NCD4A,  NCD4B, NCD4C, NCD5A,  NCD5B,  NCD5C,
     5          NCD5D, NCD6,   NCD7,  IP8,   IP9,    IP10,   ITYPE,
     6          IABAN, IFCRM,  NM,    NJT,   NST,    NLT,    M,
     7          MP1,   MP2,    ISTT,  LTT,   ITYPEL,IDJ,     NSTL
      COMMON /BLK3/ MNJT,MNST,MNLT,MNM,MNC5,MNC6,MDJT,MNJS,MNE,MNCS,
     2     MNPCS,MNSS,MNCWM,MNJST,MNJSS
      COMMON/BLK9/ NVL(20,300),   NTJ(20,300),   NVLT(300),
     2             NTJT(300),     NPTV(20),      MNPTF
      COMMON / BR / PCRML, PCRJL, NLR, NLRA
      COMMON /BLOK1/ DQXX(25), DQYY(25), DQZZ(25), DQVV(25)
      COMMON /SKT2/     WRX(25,10),   WRY(25,10),   WRZ(25,10),
     2     WRV(25,10),  WRXP(25,10), WRYP(25,10), WRTX(25,10),
     3     WRTY(25,10), WRTZ(25,10), WRTV(25,10), WRTXP(25,10),
     4     WRTYP(25,10)
      COMMON /SKT3/ NCOUNT, NITERF
      COMMON /SKT19/ JCRGCN(25,6), JCUREV(25,6)
    7 FORMAT (5X,35H       SAME AS INPUT FOR THIS PROBLEM)
    9 FORMAT ( 49H      TABLE 4A - JOINT LOADS AND LINEAR RESTRAINTS,//)
   10 FORMAT (//,45H       TABLE 4B - JOINT SUPPORT CURVE NUMBERS   ,//)
   11 FORMAT (//,40H       TABLE 4C - JOINT SUPPORT CURVES      ,//)
   12 FORMAT (I5,5X,4E10.3,/,10X,4E10.3,20X,E10.3)
   13 FORMAT ( 5X,I5,9E11.3)
   14 FORMAT  ( 25X,20H INPUT OF JOINT DATA,/)
   15 FORMAT (   43H       JOINT  FORCE(X)   FORCE(Y)  MOMENT(Z) ,
     2           44H MOMENT(V)  SPRING(X)  SPRING(Y)  SPRING(Z) ,
     3           17H SPRING(V)   MASS ,//)
   16 FORMAT ( //,25X,23H ACCUMULATED JOINT DATA,//)
   17 FORMAT ( 48H       HOLDING DATA FROM THE PREVIOUS PROBLEM PLUS,
     2        15H THE FOLLOWING ,//)
   18 FORMAT ( 48H       TABLE 4D - TIME VARYING JOINT LOADS - CURVE,
     2        28H       NUMBERS AND MULTIPLIERS,//)
   19 FORMAT (4X,50H**** LOAD REDUCTION PROBLEM - JOINT LOADS REDUCED ,
     2  F5.2,     27H PERCENT BELOW LAST PROBLEM,20(1H*),I5,
     3           16H LOAD REDUCTIONS)
   20 FORMAT ( 35H       JOINT NUMBERS MUST BE POSITIVE)
   23 FORMAT (   10H       NONE )
   30 FORMAT (   15H       NO DATA   )
   32     FORMAT (I5,5X,2E10.3,10X,6I5,5X,I5)
   33     FORMAT (5X,I5,2E11.3, 7X,6I5,5X,I5)
   35 FORMAT (    30H       JOINT    Q-MULT    W-MULT,10X,   9HNSXX NSYY,
     2            30H NSZZ NSVV NSXP NSYP      STIFF,/)
   42 FORMAT (5X,3I5,5X,11I5,/,25X,11I5)
   43 FORMAT (/,5X,3I5 ,/, 6H       Q,19X,11I5)
   44 FORMAT (            6H       W,19X,11I5)
   45 FORMAT (//,30H      CURVE NUMB SYMT (1 = YES,,/,
     2            30H       NUMB  PTS  OPT   0 = NO))
   46 FORMAT (5X,I5,5E10.3,4I5)
   50 FORMAT ( 43H      JOINT NUMBER ABOVE GREATER THAN NUMBER,
     2        20H OF JOINTS IN FRAME )
   51 FORMAT (//,45H       TABLE4E - TIME VARYING JOINT LOAD CURVES,//)
   52 FORMAT(5X,2I5,10X,11I5/(16I5))
   53 FORMAT (25X,11I5/(16I5))
   54 FORMAT (/,5X,2I5,/,9H       LOAD,19X,10I5/(28X,10I5))
   55 FORMAT (            9H       TIME,19X10I5/(28X,10I5))
   60 FORMAT (    40H       NUMBER OF CARDS IN TABLE 4C MUST BE,
     2            20H A MULTIPLE OF TWO  )
   61 FORMAT ( 40H      NUMBER OF CARDS IN TABLE 4E MUST BE,
     2        20H A MULTIPLE OF TWO  )
   62 FORMAT (    48H       NUMBER OF POINTS ON CURVE MUST BE BETWEEN 2,
     2            7H AND 10)
   63 FORMAT (5X,47HNUMBER OF POINTS ON CURVE MUST BE BETWEEN 2 AND,I5)
   70 FORMAT (    40H JOINT CURVE NUMBER TO LARGE OR NEGATIVE)
   71 FORMAT (    51H       STIFF TYPE ABOVE NOT ONE OF MEMBER STIFF TYPES,
     2            51H       STIFF TYPE REQUIRED TO REFERENCE JOINT SPRINGS)
   72 FORMAT (    17H       CURVE NUMBER,I5, 25H  NOT DEFINED IN TABLE 4C)
   73 FORMAT (    48H       NUMBER OF POINTS ON CURVE MUST BE BETWEEN 2,
     2            7H AND 11)
   74 FORMAT  (   35H       SYMMETRY OPTION MUST BE 1 OR 0)
   75 FORMAT  (   17H       CURVE NUMBER, I5,25H DOES NOT HAVE DISPLACEME,
     2            32HNTS IN ASCENDING ALGEBRAIC ORDER,/,   9H       WHEN,
     3            50H INPUT VALUES ARE MULTIPLIED BY DISPLACEMENT MULTI,
     4            14HPLIER AT JOINT)
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   76 FORMAT  (  50H       IF SYMMETRY OPTION = 1, FIRST POINT ON CURVE ,
     2            13HMUST BE  0 - 0 )
   77 FORMAT (5X,48HJOINT  FORCE(X)     FORCE(Y)    FORCE(Z)     FORCE,
     2            45H(V)          TIME        CURVE  CURVE  CURVE  CURVE,/)
   78 FORMAT(12X,48HMULT             MULT            MULT            MULT      ,
     2            37H  MULT           (X)      (Y)      (Z)      (V),/)
   79 FORMAT(72X,25HNUMB    NUMB    NUMB    NUMB,//)
   80 FORMAT (5X,I5,5(2X,E10.3),4(2X,I5))
   81 FORMAT (5X,11HCURVE  NUMB,/
     2            6X,9HNUMB  PTS,//)
   85 FORMAT (///)
COMMENT - CHECK FOR LOAD REDUCTION
          IF ( NLR .EQ. 0 ) GO TO 1100
              FAC = 1.0 - PCRJL / 100.0
          DO 1050 I = 1,NJT
              ERXX(I) = QXX(I) - DQXX(I)
              ERYY(I) = QYY(I) - DQYY(I)
              ERZZ(I) = QZZ(I) - DQZZ(I)
              ERVV(I) = QVV(I) - DQVV(I)
              QXX  (I) = FAC * QXX  (I)
              QYY  (I) = FAC * QYY  (I)
              QZZ  (I) = FAC * QZZ  (I)
              QVV  (I) = FAC * QVV  (I)
 1050     CONTINUE
      PRINT 19 , PCRJL, NLR
          GO TO 3100
 1100     CONTINUE
COMMENT - INPUT TABLE 4A
      PRINT 9
          IF ( ITYPE .EQ. 1 .OR. ITYPE .EQ. 9 ) GO TO 1120
          DO 1110  I = 1,NJT
              ERXX(I) = QXX(I)
              ERYY(I) = QYY(I)
              ERZZ(I) = QZZ(I)
              ERVV(I) = QVV(I)
 1110     CONTINUE
 1120     CONTINUE
          IF (KEEP4A .EQ. 1) GO TO 1230
COMMENT - ZERO JOINT DATA
          DO 1200 I = 1, MNJT
              QXX(I) = 0.0
              QYY(I) = 0.0
              QZZ(I) = 0.0
              QVV(I) = 0.0
              SXX(I) = 0.0
              SYY(I) = 0.0
              SZZ(I) = 0.0
              SVV(I) = 0.0
 1200         ZMASS(I) = 0.0
          IF (NCD4A .NE. 0) GO TO 1240
      PRINT 30
          GO TO 3000
COMMENT - HOLDING DATA
 1230 PRINT 17
          IF (NCD4A .NE. 0) GO TO 1240
      PRINT 23
          GO TO 3000
 1240     CONTINUE
      PRINT 14
      PRINT 15
          DO 2900  II = 1, NCD4A
COMMENT - READ AND PRINT DATA FOR EACH JOINT
          READ 12, I,QXXT,QYYT,QZZT,QVVT,SXXT,SYYT,SZZT,SVVT,ZMASST
          PRINT 13, I,QXXT,QYYT,QZZT,QVVT,SXXT,SYYT,SZZT,SVVT,ZMASST
          IF (I .GT. NJT) GO TO  8500
          IF (I .LE. 0 ) GO TO  8200
COMMENT - ACCUMULATE DATA
              QXX(I) = QXX(I) + QXXT
              QYY(I) = QYY(I) + QYYT
              QZZ(I) = QZZ(I) + QZZT
              QVV(I) = QVV(I) + QVVT
              SXX(I) = SXX(I) + SXXT
              SYY(I) = SYY(I) + SYYT
              SZZ(I) = SZZ(I) + SZZT
              SVV(I) = SVV(I) + SVVT
              ZMASS(I) = ZMASS(I)+ZMASST
 2900     CONTINUE
 3000     CONTINUE
          IF ( ITYPE .EQ. 1 .OR. ITYPE .EQ. 9 ) GO TO 3800
 3100     CONTINUE
          DO 3600  I = 1,NJT
              ERXX(I) = QXX(I) - ERXX(I)
              ERYY(I) = QYY(I) - ERYY(I)
              ERZZ(I) = QZZ(I) - ERZZ(I)
              ERVV(I) = QVV(I) - ERVV(I)
 3600     CONTINUE
          IF ( NLR .GT. 0 ) GO TO 4820
          GO TO 4000
 3800     CONTINUE
          DO 3900 I =   1,NJT
              ERXX(I) = QXX(I)
              ERYY(I) = QYY(I)
              ERZZ(I) = QZZ(I)
              ERVV(I) = QVV(I)
 3900     CONTINUE
 4000     CONTINUE
```

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COMMENT - PRINT ACCUMULATED JOINT DATA UNLESS IT IS THE SAME AS INPUT
COMMENT - FOR THIS PROBLEM
          IF (KEEP4A .EQ. 1) GO TO 4820
          IF (NCD4A .EQ. 0) GO TO 4865
      PRINT 16
      PRINT 7
          GO TO 4865
 4820     CONTINUE
      PRINT 16
      PRINT 15
          DO 4860 I = 1, NJT
          IF (QXX(I) .NE. 0) GO TO 4850
          IF (QYY(I) .NE. 0) GO TO 4850
          IF (QZZ(I) .NE. 0) GO TO 4850
          IF (QVV(I) .NE. 0) GO TO 4850
          IF (SXX(I) .NE. 0) GO TO 4850
          IF (SYY(I) .NE. 0) GO TO 4850
          IF (SZZ(I) .NE. 0) GO TO 4850
          IF (SVV(I) .NE. 0) GO TO 4850
          IF (ZMASS(I).NE.0.0)GO TO 4850
          GO TO 4860
 4850 PRINT 13, I,QXX(I),QYY(I),QZZ(I),QVV(I),SXX(I),SYY(I),SZZ(I),
     2          SVV(I),ZMASS(I)
 4860     CONTINUE
 4865     CONTINUE
          DO 4900 I = 1,NJT
               DQXX(I) = ERXX(I)
               DQYY(I) = ERYY(I)
               DQZZ(I) = ERZZ(I)
               DQVV(I) = ERVV(I)
 4900     CONTINUE
          IF ( NLR .NE. 0 ) GO TO 9900
COMMENT - INPUT TABLE 4B
      PRINT 10
          IF (KEEP4B .EQ. 1) GO TO 5230
COMMENT - ZERO CURVE NUMBERS
          DO 5200 I = 1, MNJT
               NSXX(I) = 0.0
               NSYY(I) = 0.0
               NSZZ(I) = 0.0
               NSVV(I) = 0.0
               NSXP(I) = 0.0
 5200          NSYP(I) = 0.0
          IF (NCD4B .NE. 0) GO TO 5240
      PRINT 30
      GO TO 6000
COMMENT - HOLDING DATA
 5230 PRINT 17
          IF (NCD4B .NE. 0) GO TO 5240
      PRINT 23
      GO TO 6000
 5240 CONTINUE
      PRINT 14
      PRINT 35
          DO 5900  II = 1, NCD4B
COMMENT - READ AND PRINT ONE DATA CARD
          READ 32,I,QMJ(I),WMJ(I),NSXX(I),NSYY(I),NSZZ(I),NSVV(I),
     2     NSXP(I),NSYP(I),ISTJR(I)
          PRINT 33,I,QMJ(I),WMJ(I),NSXX(I),NSYY(I),NSZZ(I),NSVV(I),
     2     NSXP(I),NSYP(I),ISTJR(I)
          IF (I .GT. NJT) GO TO  8500
          IF (I .LE. 0 ) GO TO  8200
          IF (NSXX(I) .GT. MNJS .OR. NSXX(I) .LT. 0) GO TO 8700
          IF (NSYY(I) .GT. MNJS .OR. NSYY(I) .LT. 0) GO TO 8700
          IF (NSZZ(I) .GT. MNJS .OR. NSZZ(I) .LT. 0) GO TO 8700
          IF (NSVV(I) .GT. MNJS .OR. NSVV(I) .LT. 0) GO TO 8700
          IF (NSXP(I) .GT. MNJS .OR. NSXP(I) .LT. 0) GO TO 8700
          IF (NSYP(I) .GT. MNJS .OR. NSYP(I) .LT. 0) GO TO 8700
          IF (NSXP(I) + NSYP(I) .EQ. 0)  GO TO 5800
          IF (ISTJR(I) .LE. 0 .OR. ISTJR(I) .GT. NST) GO TO 8710
 5800     CONTINUE
 5900     CONTINUE
 6000     CONTINUE
COMMENT - PRINT ACCUMULATED JOINT DATA UNLESS IT IS THE SAME AS INPUT
COMMENT - FOR THIS PROBLEM
          IF (KEEP4B .EQ. 1) GO TO 6820
          IF (NCD4B .EQ. 0) GO TO 6865
      PRINT 16
      PRINT 7
      GO TO 6865
 6820     CONTINUE
      PRINT 16
      PRINT 35
          DO 6860  I = 1,NJT
          IF (NSXX(I) .NE. 0) GO TO 6850
          IF (NSYY(I) .NE. 0) GO TO 6850
          IF (NSZZ(I) .NE. 0) GO TO 6850
          IF (NSVV(I) .NE. 0) GO TO 6850
          IF (NSXP(I) .NE. 0) GO TO 6850
          IF (NSYP(I) .NE. 0) GO TO 6850
          GO TO 6860
 6850     PRINT 33,I,QMJ(I),WMJ(I),NSXX(I),NSYY(I),NSZZ(I),NSVV(I),
     2     NSXP(I),NSYP(I),ISTJR(I)
 6860     CONTINUE
 6865     CONTINUE
COMMENT - INPUT TABLE 4C
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      PRINT 11
         IF (KEEP4C .EQ. 1) GO TO 7230
COMMENT - INITIALIZE NUMBER OF POINTS ON CURVE
         DO 7200  J = 1,MNJS
 7200       NPT(J) = -1
         IF (NCD4C .NE. 0) GO TO 7240
      PRINT 30
         GO TO 7500
COMMENT - HOLDING DATA
 7230 PRINT 17
         IF (NCD4C .NE. 0) GO TO 7240
      PRINT 23
         GO TO 7500
 7240    CONTINUE
      PRINT 14
      PRINT 45
            NCD4C2 = NCD4C/2
         IF (NCD4C2*2 .NE. NCD4C) GO TO 8600
      DO 7350  II = 1,NCD4C2
      READ 42, NC,NPTT,ISJT,(NQJT(I), I = 1,11),(NWJT(I), I = 1,11)
         DO 7310  I = 1,NPTT
            NQJ(NC,I) = NQJT(I)
            NWJ(NC,I) = NWJT(I)
 7310    CONTINUE
            NPT(NC) = NPTT
            ISJ(NC) = ISJT
      PRINT 43, NC,NPT(NC),ISJ(NC),(NQJ(NC,I), I = 1,NPTT)
      PRINT 44, (NWJ(NC,I), I = 1,NPTT)
         IF (ISJT .EQ. 1 .AND. NQJT(1) .NE. 0) GO TO 8760
         IF ( ISJT .EQ. 1 .AND. NWJT(1) .NE. 0)  GO TO 8760
         IF (NC .LT. 0 .OR. NC .GT. MNJS)  GO TO 8700
         IF (NPTT .LT. 2 .OR. NPTT .GT. 11) GO TO 8730
         IF (ISJT .NE. 0 .AND. ISJT .NE. 1) GO TO 8740
COMMENT - SUBROUTINE  JNTCUR(NC)  DECOMPOSES NON-LINEAR JOINT-SUPPORT
C         (BASIC) CURVE NUMBER  NC  INTO THE COMPONENTS
     CALL          JNTCUR (NC)
 7350    CONTINUE
 7500    CONTINUE
COMMENT - CHECK FOR CURVE REFERENCED IN TABLE 4B BUT NOT IN TABLE 4C
COMMENT - AND FOR DISPLACEMENT VALUES NOT IN ASCENDING ALGEBRAIC ORDER
         DO 7700 I = 1,NJT
         IF (NSXX(I) .EQ. 0) GO TO 7510
            NC = NSXX(I)
         IF (NPT(NC) .EQ. -1) GC TO 8720
            NPTT = NPT(NC)
         DO 7505  II = 2,NPTT
         IF ( WMJ(I)*(NWJ(NC,II) - NWJ(NC,II - 1)).LE. 0.0)  GO TO 8750
 7505    CONTINUE
 7510    IF (NSYY(I) .EQ. 0) GO TO 7520
            NC = NSYY(I)
         IF (NPT(NC) .EQ. -1) GO TO 8720
            NPTT = NPT(NC)
         DO 7515  II = 2,NPTT
         IF ( WMJ(I)*(NWJ(NC,II) - NWJ(NC,II - 1)).LE. 0.0)  GO TO 8750
 7515    CONTINUE
 7520    IF (NSZZ(I) .EQ. 0) GO TO 7526
            NC = NSZZ(I)
         IF (NPT(NC) .EQ. -1) GO TO 8720
            NPTT = NPT(NC)
         DO 7525  II = 2,NPTT
         IF ( WMJ(I)*(NWJ(NC,II) - NWJ(NC,II - 1)).LE. 0.0)  GO TO 8750
 7525    CONTINUE
 7526    IF (NSVV(I) .EQ. 0) GC TO 7530
            NC = NSVV(I)
         IF (NPT(NC) .EQ. -1) GO TO 8720
            NPTT = NPT(NC)
         DO 7528  II = 2,NPTT
         IF ( WMJ(I)*(NWJ(NC,II) - NWJ(NC,II - 1)).LE. 0.0)  GO TO 8750
 7528    CONTINUE
 7530    IF (NSXP(I) .EQ. 0) GO TO 7540
            NC = NSXP(I)
         IF (NPT(NC) .EQ. -1) GO TO 8720
            NPTT = NPT(NC)
         DO 7535  II = 2,NPTT
         IF ( WMJ(I)*(NWJ(NC,II) - NWJ(NC,II - 1)).LE. 0.0)  GO TO 8750
 7535    CONTINUE
 7540    IF ( NSYP(I) .EQ. 0) GO TO 7700
            NC = NSYP(I)
         IF (NPT(NC) .EQ. -1) GC TO 8720
            NPTT = NPT(NC)
         DO 7545  II = 2,NPTT
         IF ( WMJ(I)*(NWJ(NC,II) - NWJ(NC,II - 1)).LE. 0.0)  GO TO 8750
 7545    CONTINUE
 7700    CONTINUE
         IF ( NCD4E .LE. 0 ) GO TO 7720
            NCOUNT = 1
         DO 7715 I = 1,NJT
COMMENT - SUBROUTINE  CURDET(I)  PRINTS DETAILS OF NON-LINEAR
C         JOINT-SUPPORT CURVES AT JOINT  I.
     CALL          CURDET ( I )
 7715 CONTINUE
 7720 CONTINUE
         IF ( ITYPE .NE. 1 ) GO TO 8000
COMMENT - INITIALISE THE RESIDUAL & TEMPORARY RESIDUAL DISPLACEMENTS
C         FOR ALL THE JOINT-SUPPORT SPRINGS
         DO 7800 I = 1,MNJT
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          DO 7800 J = 1,10
                WRX   (I,J) = 0.0
                WRTX  (I,J) = 0.0
                WRY   (I,J) = 0.0
                WRTY  (I,J) = 0.0
                WRZ   (I,J) = 0.0
                WRTZ  (I,J) = 0.0
                WRV   (I,J) = 0.0
                WRTV  (I,J) = 0.0
                WRXP  (I,J) = 0.0
                WRTXP (I,J) = 0.0
                WRYP  (I,J) = 0.0
                WRTYP (I,J) = 0.0
 7800 CONTINUE
COMMENT - INITIALISE THE REVERSAL INDICATORS FOR ALL THE
COMMENT - FIVE SPRINGS AT EACH JOINT
          DO 7900 I = 1,MNJT
          DO 7900 N = 1,6
             JCUREV(I,N) = 0
 7900     CONTINUE
 8000 CONTINUE
      PRINT 85
COMMENT - INPUT TABLE 4D
      PRINT 18
          IF(KEEP4D.EQ.1)GO TO 9960
COMMENT - ZERO TIME VARYING LOAD CURVE NUMBERS
          DO 9950 I = 1,MNJT
             NFTXX(I) = 0
             NFTYY(I) = 0
             NFTZZ(I) = 0
             NFTVV(I) = 0
 9950 CONTINUE
          IF(NCD4D.NE.0)GO TO 9970
      PRINT 30
      GO TO 10000
COMMENT - HOLDING DATA
 9960 PRINT 17
          IF(NCD4D.NE.0)GO TO 9970
      PRINT 23
      GO TO 10000
 9970 CONTINUE
      PRINT 14
      PRINT 77
      PRINT 78
      PRINT 79
          DO 9980 II = 1,NCD4D
COMMENT - READ AND PRINT ONE DATA CARD
      READ 46,I,FTMJXX(I),FTMJYY(I),FTMJZZ(I),FTMJVV(I),TTMJ(I),
     2    NFTXX(I),NFTYY(I),NFTZZ(I),NFTVV(I)
      PRINT 80,I,FTMJXX(I),FTMJYY(I),FTMJZZ(I),FTMJVV(I),TTMJ(I),
     2    NFTXX(I),NFTYY(I),NFTZZ(I),NFTVV(I)
          IF(I.GT.NJT)GO TO 8500
          IF(I.LE.0)GO TO 8200
          IF (NFTXX(I).GT.MNTVJL.OR.NFTXX(I).LT.0)GO TO 8700
          IF (NFTYY(I).GT.MNTVJL.OR.NFTYY(I).LT.0)GO TO 8700
          IF (NFTZZ(I).GT.MNTVJL.OR.NFTZZ(I).LT.0)GO TO 8700
          IF (NFTVV(I).GT.MNTVJL.OR.NFTVV(I).LT.0)GO TO 8700
 9980 CONTINUE
10000 CONTINUE
          IF(KEEP4D.EQ.1)GO TO 10500
          IF(NCD4D.EQ.0)GO TO 10510
      PRINT 16
      PRINT 7
      GO TO 10510
10500     CONTINUE
      PRINT 16
      PRINT 77
      PRINT 78
      PRINT 79
          DO 10508 I = 1,NJT
          IF(NFTXX(I).NE.0)GO TO 10505
          IF(NFTYY(I).NE.0)GO TO 10505
          IF(NFTZZ(I).NE.0)GO TO 10505
          IF(NFTVV(I).NE.0)GO TO 10505
      GO TO 10508
10505 PRINT 80,I,FTMJXX(I),FTMJYY(I),FTMJZZ(I),FTMJVV(I),TTMJ(I),
     2    NFTXX(I),NFTYY(I),NFTZZ(I),NFTVV(I)
10508     CONTINUE
10510 CONTINUE
COMMENT - INPUT TABLE 4E
      PRINT 51
          IF (KEEP4E.EQ.1)GO TO 11000
COMMENT - INITIALIZE NUMBER OF POINTS IN CURVE
          DO 10800 J = 1,MNTVJL
10800        NPTV(J) = -1
          IF (NCD4E.NE.0)GO TO 10900
      PRINT 30
      GO TO 11400
COMMENT - HOLDING DATA
11000 PRINT 17
          IF(NCD4E.NE.0)GO TO 10900
      PRINT 23
      GO TO 11400
10900     CONTINUE
      PRINT 14
             NCD4E2 = NCD4E/2
```

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          IF (NCD4E2*2 .NE. NCD4E)GO TO 8650
      DO 11300 II = 1,NCD4E2
      READ 52, NC,NPTVV,(NVLT(I), I = 1,NPTVV)
      READ 53,(NTJT(I), I = 1,NPTVV)
      DO 11250 I = 1,NPTVV
          NVL(NC,I) = NVLT(I)
          NTJ(NC,I) = NTJT(I)
11250 CONTINUE
          NPTV(NC) = NPTVV
11200 CONTINUE
      PRINT 16
      PRINT 81
      PRINT 54, NC,NPTV(NC),(NVL(NC,I), I = 1,NPTVV)
      PRINT 85
      PRINT 55, (NTJ(NC,I), I = 1,NPTVV)
          IF (NC.LT.0.OR.NC.GT.MNIVJL)GO TO 8700
          IF ( NPTVV .LT. 2 .OR. NPTVV .GT. MNPTF ) GO TO 8735
11300 CONTINUE
11400     CONTINUE
          GO TO 9900
 8200 PRINT 20
          GO TO 9700
 8500 PRINT 50
          GO TO 9700
 8600 PRINT 60
          GO TO 9700
 8650 PRINT 61
          GO TO 9700
 8700 PRINT 70
          GO TO 9700
 8735 PRINT 63, MNPTF
          GO TO 9700
 8710 PRINT 71
          GO TO 9700
 8720 PRINT 72,NC
          GO TO 9700
 8730 PRINT 73
          GO TO 9700
 8740 PRINT 74
          GO TO 9700
 8750 PRINT 75, NC
          GO TO 9700
 8760     PRINT 76
 9700         IABAN = 1
 9900     CONTINUE
      RETURN
      END

************************************ SUBROUTINE ***********************************
      SUBROUTINE   JNTCUR ( NC )
COMMENT - SUBROUTINE  JNTCUR(NC)  DECOMPOSES THE NON-LINEAR
C         JOINT-SUPPORT (BASIC) CURVE NUMBER  NC  INTO THE COMPONENTS
C         NOTE THAT ONLY THE UNSCALED VIRGIN INTEGER INPUT CURVE
C         IS BEING USED HERE.  THE PROPER SCALE-FACTORS ARE TAKEN
C         CARE OF AT THE PROPER PLACES IN THE RELEVANT
C         SUBROUTINES ( CURDET  AND  INELST  )
COMMENT - AT PRESENT THE SUBROUTINE CAN HANDLE ONLY CURVES PASSING
COMMENT - THROUGH ORIGIN
COMMENT - DESCENDING BRANCHES ARE NOT CONSIDERED AND HENCE SHOULD NOT
COMMENT - BE INPUT
COMMENT - THE PROGRAM AUTOMATICALLY CONSIDERS SYMMETRY (THAT IS NEGATIVE
COMMENT - QUADRANT IS ANTISYMMETRIC IMAGE OF POSITIVE QUADRANT)
COMMENT - NO LIMIT IS FIXED ON MAXIMUM DEFORMATION
COMMENT - A HORIZONTAL LINE (THAT IS PARELLEL TO DEFORMATION AXIS)
COMMENT - IS FORMED FROM THE TOPMOST INPUT POINT OF THE CURVE
      IMPLICIT REAL  * 8 (A-H,O-Z)
      DIMENSION QQ (11), WW (11), RMAX (10)
      COMMON /BLOCK8/ NPT( 20),     ISJ( 20),    NQJ( 20,11),NWJ( 20,11),
     2     NQJT(11),    NWJT(11)
        COMMON /SKT1/          WWJT(20,10),    RMAXJT(20,10)
             NPTT = NPT (NC)
             NPTM1 = NPTT - 1
             NPTM2 = NPTT - 2
        DO 110 I = 1,NPTT
             QQ  (I) = NQJ  (NC,I)
             WW  (I) = NWJ  (NC,I)
  110 CONTINUE
        IF ( NPTM2 .EQ. 0 ) GO TO 205
        DO 200 I = 1,NPTM2
             SLOK = ( QQ(I+1)  - QQ(I)  ) / ( WW(I+1)  - WW(I)  )
             SLOKE1=( QQ(I+2)  - QQ(I+1))/ ( WW(I+2)  - WW(I+1))
             STF = SLOK - SLOKE1
             RMAX (I) = WW  (I+1 ) * STF
  200 CONTINUE
  205 CONTINUE
             STF = ( QQ(NPTT)  - QQ(NPTM1)  ) / ( WW(NPTT)  - WW(NPTM1) )
             RMAX  (NPTM1) = WW(NPTT) * STF
        DO 220 I = 1,NPTM1
             WWJT   (NC,I) = WW   (I+1)
             RMAXJT (NC,I) = RMAX (I)
  220 CONTINUE
COMMENT - WWJT  &  RMAXJT  DENOTE THAT THEY ARE DERIVED FROM
C         THE (BASIC) INTEGER INPUT CURVES
      RETURN
      END
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************************************ SUBROUTINE **************************************
      SUBROUTINE  CURDET ( JTN )
COMMENT - CURDET (JTN) PRINTS THE DETAILS OF THE NON-LINEAR
C         JOINT-SUPPORT CURVES ( MAXIMUM  6 PER JOINT ) AT THE
C         JOINT NUMBER  JTN.  THESE ARE OBTAINED BY MULTIPLYING
C         THE ABSCISSAE & ORDINATES OF THE PRESCRIBED CURVE NUMBER
C         BY THE RELEVENT SCALE-FACTORS FOR THE JOINT
COMMENT - THIS SUBROUTINE IS NORMALLY CALLED CNLY ONCE FOR EACH JOINT.
C         IN THE UNUSUAL CASE IN WHICH ADDITIONAL NON-LINEAR SUPPORTS
C         ARE INTRODUCED (OR EXISTING ONES ARE MODIFIED) AT ONE
C         OR MORE JCINTS UNDER  ITYPE > = 2, THEN SUBROUTINE CURDET
C         WILL AGAIN BE ACCESSED AND THERE MIGHT BE SOME REDUNDANT
C         REPETITIVE PRINTING OF THE DETAILS OF THE OLD CURVES
C         ALONG WITH THE NEW ONES.
      IMPLICIT  REAL * 8  (A-H,O-Z)
      DIMENSION QQ (11), WW (11), RMAX (10)
      COMMON /BLOCK1/ X(25),       Y(25),       QXX(25),     QYY(25),
     2    QZZ(25),     SXX(25),     SYY(25),     SZZ(25),     DXX(25),
     3    DYY(25),     DZZ(25),     RXX(25),     RYY(25),     RZZ(25),
     4    ERXX(25),    ERYY(25),    ERZZ(25),    QMJ(25),     WMJ(25),
     5    NSXX(25),    NSYY(25),    NSZZ(25),    IMJ(25),     NSXP(25),
     6    NSYP(25),    ISTJR(25)
      COMMON /BALA01/ QVV(25),     SVV(25),     DVV(25),     ERVV(25),
     2    RVV(25),     NSVV(25)
      COMMON /BLOCK8/ NPT( 20),    ISJ( 20),    NQJ( 20,11),NWJ( 20,11),
     2    NQJT(11),    NWJT(11)
      COMMON /SKT1/         WWJT(20,10),   RMAXJT(20,10)
      COMMON /SKT3/ NCOUNT, NITERF
    2 FORMAT (10X,4(E11.4,4X))
    9 FORMAT (/)
   10 FORMAT ( // )
   89 FORMAT ( 10X,40HORIENTATIONS OF JOINT SPRING GIVEN BELOW)
   90 FORMAT ( 10X,49HDETAILS OF JOINT SUPPORT CURVES AT JOINT NUMBER =,
     1    I5)
   95 FORMAT ( 10X,27HSPRING NUMBER      REFERS TO,/,
     2         16X,1H1,11X,8HX SPRING,/,
     3         16X,1H2,11X,8HY SPRING,/,
     4         16X,1H3,11X,8HZ SPRING,/,
     5         16X,1H4,11X,8HV SPRING,/,
     6         16X,1H5,11X,14HX PRIME SPRING,/,
     7         16X,1H6,11X,14HY PRIME SPRING )
  100 FORMAT ( 10X,15HSPRING NUMBER =,I3,5X,19HNUMBER OF COMPONENT,
     2         12H SPRINGS    =,I3)
  104 FORMAT (10X,12HDEFCRMATIONS,3X,11HRESISTANCES,4X,12HSTIFFNESS OF,
     2 3X,   14HMAX RESISTANCE)
  106 FORMAT (10X,5HINPUT,10X,5HINPUT,10X,10HCOMPONENTS,5X,7HOF COMP,
     2   6HONENTS,/)
      DO 4000 JSPR = 1,6
      GO TO ( 3001, 3002, 3003, 3004, 3005, 3006 ), JSPR
 3001            NC = NSXX ( JTN )
      GO TO 3500
 3002            NC = NSYY ( JTN )
      GO TO 3500
 3003            NC = NSZZ ( JTN )
      GO TO 3500
 3004            NC = NSVV(JTN)
         GO TO 3500
 3005            NC = NSXP ( JTN )
      GO TO 3500
 3006            NC = NSYP ( JTN )
 3500 CONTINUE
         IF ( NC .EQ. 0 ) GO TO 4000
            NPTT = NPT (NC)
            NPTM1 = NPTT - 1
         DO 3600 I = 1,NPTT
            QQ (I) = QMJ (JTN) * NQJ (NC,I)
            WW (I) = WMJ (JTN) * NWJ (NC,I)
         IF ( I .EQ. NPTT ) GO TO 3600
            RMAX (I) = QMJ (JTN) * RMAXJT (NC,I)
 3600 CONTINUE
      PRINT 10
         IF ( NCOUNT .NE. 1 ) GO TO 3700
      PRINT 89
      PRINT 9
      PRINT 95
      PRINT 10
 3700 CONTINUE
      PRINT 90, JTN
      PRINT 9
      PRINT 100, JSPR, NPTM1
      PRINT 9
      PRINT 104
      PRINT 106
      PRINT 2, WW(1), QQ(1)
         DO 3800 I = 2,NPTT
            STF = RMAX (I-1) / WW (I)
 3800 PRINT 2, WW(I), QQ(I), STF, RMAX(I-1)
            NCOUNT = NCOUNT + 1
 4000 CONTINUE
      RETURN
      END
```

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*********************************** SUBROUTINE ***********************************
      SUBROUTINE RDMST
COMMENT - SUBROUTINE RDMST  INPUTS MEMBER STIFFNESS DATA (TABLE 5),
COMMENT - CHECKS FOR BAD DATA,CONVERTS INPUT DISTANCES TO MEMBER
COMMENT - COORDINATES AND ECHO PRINTS DATA
      IMPLICIT REAL*8 (A-H,O-Z)
      DIMENSION NOTE(25)
      COMMON /BLOCK2/ DXS( 25),     DYS( 25),     ZLS( 25),     DC1S( 25),
     2     DC2S( 25),    PRF( 25),     PRAE( 25),    QM( 25),      WM( 25),
     3     PRAG(25),     ELEMN(25),
     4     IOPOP( 25),   IPINL( 25),   IPINR( 25),   NC51( 25),    INLOP( 25),
     5     NAL( 25),     NSXL( 25),    NSYL( 25),    NSZL( 25),    NAR( 25),
     6     NSXR( 25),    NSYR( 25),    NSZR( 25),    NCDS( 25),    IAXOPS( 25)
      COMMON /BLOCK4/ FOMM(50,6),SMC(50,21),IST(50),     LT(50),
     2     JT1(50),      JT2(50),         NITM(50),     IMM(50),      IMC(50)
      COMMON /BLOCK5/ XLS( 50),     XRS( 50),     FL( 50),      AEL( 50),
     2     SXL( 50),     SYL( 50),     SZL( 50)
      COMMON /BALA12/ SHC(20,10)
      COMMON /BLOC12/ SM(20,10),    EM(20,10),    BI(20,10),    DI(20,10),
     2     YI(20,10),    NSS(20,10),   NA(20),       NCDA(20),     IRECT(20,10)
      COMMON /BALA13/ GS(08)
      COMMON /BLOC13/ NPTS( 08),    ISS( 08),  NSIG(08,11),NEPS(08,11),
     2     NSIT(11),     NEPT(11)
      COMMON /BLOC14/ NPTM( 20),    ISM( 20),  NQM(20,11), NWM(20,11),
     2     NQMT(11),     NWMT(11)
      COMMON /BLK1/   TOL,      ELEMNT,NJST,   KEEP3C,NCD3C,
     2           KEEP2, KEEP3A,KEEP3B,KEEP4A,KEEP4B,KEEP4C,KEEP5A,
     3           KEEP5B,KEEP5C,KEEP5D,KEEP6, KEEP7,  NCD2,   NCD3A,
     4           NCD3B, NCD4A, NCD4B, NCD4C, NCD5A,  NCD5B,  NCD5C,
     5           NCD5D, NCD6,  NCD7,  IP8,   IP9,    IP10,   ITYPE,
     6           IABAN, IFORM, NM,    NJT,   NST,    NLT,    M,
     7           MP1,   MP2,   ISTT,  LTT,   ITYPEL,IDJ,     NSTL
      COMMON /BLK3/ MNJT,MNST,MNLT,MNM,MNC5,MNC6,MDJT,MNJS,MNE,MNCS,
     2     MNPCS,MNSS,MNQWM,MNJST,MNJSS
      COMMON /SKT10/        NDIV(20,10),      NPCTOT(20)
      COMMON /SKT11/        MSSINL,           MSSIM1
      COMMON /SKT30/ MSTIF(25), MLOAD(25), MODEL(25)
      COMMON /SKT31/ ALPHA  (8), BETA   (8), SMLSLP(8), EPSTHD(8),
     2               SLOPBD(8), SIGULT(8), MATRL  (8)
    6 FORMAT  (  /,42H      TABLE 5D - SUPPORT CURVES FOR MEMBERS,/)
    7 FORMAT  (  /,36H      TABLE 5C - STRESS STRAIN CURVES,/)
    8 FORMAT  (  /,35H        TABLE 5B - CROSS SECTION DATA ,/)
    9 FORMAT  (   40H      TABLE 5A - MEMBER STIFFNESS DATA    ,  /)
   12 FORMAT  (   2I5,E10.3,A5,5X,2E10.3,6I5)
   13 FORMAT  (   2I5,E10.3,2X,A5,2X,2E10.3,4I5,5X,2I5)
   14 FORMAT  (//,48H STIF   #OF   MOD OF    ELEMENT PRISMATIC PRISMATIC,
     2            35H  NON NUMB AXIS  OUTPUT   PIN  PIN , /,
     3            48H TYPE ELEM  ELAST     TYPE         I          A      ,
     4            35H  LIN CRDS  OPT    OPT     FROM   TO ,//)
   15 FORMAT  (10X,7E10.3)
   16 FORMAT  ( 5X,7E11.3)
   17 FORMAT  (   48H        HOLDING DATA FROM THE PREVIOUS PROBLEM PLUS,
     2            15H THE FOLLOWING ,/)
   18 FORMAT  (/,20H              STIFF TYPE, I5,6H CONTD,5X,/,
     2        3X, 47H       FROM          TO          I          A      ,
     3            30H      SX          SY          SZ,/)
   19 FORMAT  (10X,4I5,5X,4I5,5X,2E10.3)
   20 FORMAT  (/,15H      STIFF TYPE, I5,6H CONT ,/,
     2 45H        FROM JOINT                      TO JOINT ,/,
     3 50H        NA  NSX  NSY  NSZ            NA  NSX  NSY  NSZ,
     4 26H       Q - MULT    W - MULT,/, 5X,4I5,5X,4I5,5X,2E11.3)
   23 FORMAT  (   10H        NONE )
   30 FORMAT  (   25H        NO DATA IN TABLE      )
   31 FORMAT  (   51H        NUMBER OF CARDS TO FOLLOW MUST NOT BE NEGATIVE)
   32 FORMAT  (   35H        OUTPUT OPTION MUST BE 0 OR 1  )
   33 FORMAT  (   45H        PIN OPTION MUST NOT BE GREATER THAN ONE )
   34 FORMAT  (   40H        NON LINEAR OPTION MUST BE 0 OR 1    )
   35 FORMAT  (   48H        CROSS-SECTION NUMBER TOO LARGE OR NO CROSS-,
     2            25HSECTION NUMBER SPECIFIED )
   41 FORMAT  (//,30H        INPUT OF CROSS SECTIONS  , // )
   42 FORMAT  (5X,2I5)
   43 FORMAT  (5X,50HCROS NUMB SUB WIDTH OR DEPTH OR     Y-CENT  RECT =0,
     2            36H  SIG-EP   SIG-MUL  EP-MUL   SH-COEF,/,
     3       5X,  49HSECT CRDS DIV  O-DIA   THICKNESS               PIPE=1,
     4       2X,   4HNUMB,/)
   44 FORMAT  (   5X, 2(I3,2X) )
   45 FORMAT  (   5X,I5, 3E10.3, 2I5, 3E10.3 )
   46 FORMAT  (   15X, I2, 1X, 3E10.3, 2I5, 5X, 3E10.3 )
   47 FORMAT  (   15X, A1, 2X, 3E10.3, 2I5, 5X, 3E10.3 )
   51 FORMAT  (   35H        STIFF DATA MUST START AT 0.0  )
   52 FORMAT  (   40H        STIFF DATA MUST STOP AT END OF MEMB)
   53 FORMAT  (   50H        STIFF SEQUENCE MUST BE LONGER THAN 1/M *SPAN )
   54 FORMAT  (   50H        STIFF DATA MUST BE SPECIFIED CONTINUOUSLY,IE ,
     2            35H FROM DIST MUST EQUAL LAST TO DIST )
   55 FORMAT  (   48H        NO CARDS IN TABLE 5 BUT STIFF TYPES NOT ALL,
     2            10H SPECIFIED)
   56 FORMAT  (   49H        ALL CARDS SPECIFIED FOR TABLE 5 READ BUT ALL,
     2            26H STIFF TYPES NOT SPECIFIED,/,
     3            47H        CHECK CARD COUNT AND NUMBER OF STIFF TYPES)
   57 FORMAT  (   48H        ALL STIFF TYPES SPECIFIED BUT ALL CARDS NOT,
     2             5H READ,/,
     3            47H        CHECK CARD COUNT AND NUMBER OF STIFF TYPES)
   58 FORMAT  (   35H        AXIS OPTION MUST EQUAL 1 OR 2 )
   60 FORMAT  (   50H        NEGATIVE VALUES OF A      I ARE NOT PERMITTED)
   65 FORMAT  (   45H        STIFF TYPES MUST BE IN ASCENDING ORDER   )
   67 FORMAT  (   50H        IF 2ND CARD USED FOR STIFF TYPE, PRISMATIC I ,
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     2     20H AND A  MUST BE 0.0 )
 61  FORMAT (  50H     IF NONLINEAR OPTION = 1, TABLE 5E MUST HAVE  ,
     2     10HSOME DATA )
 71  FORMAT  (   40H     STIFF TYPES MUST NOT BE NEGATIVE    )
 72  FORMAT  (   50H     STIFF TYPE GREATER THAN TOTAL NUMBER OF STIFF,
     2     20H TYPES SPECIFIED        )
 73  FORMAT  (   47H     NUMBER OF CARDS IN THIS TABLE MUST BE EVEN)
 74  FORMAT  (   48H     NON LINEAR OPTION MAY NOT BE 1 IF NUMBER OF,
     2     25H CARDS THAT FOLLOWS IS 0 )
 75  FORMAT  (   50H     TOO LARGE A NUMBER FOR Q-W CURVE NUMBER OR NO,
     2     24H CURVE NUMBER SPECIFIED )
 76  FORMAT  (   31H     AREA OPTION MUST BE 1 OR 0)
 77  FORMAT  (   50H     TOO LARGE A NUMBER FOR STRESS-STRAIN CURVE NU,
     2     35HMBER OR NO CURVE NUMBER SPECIFIED )
 78  FORMAT  (   48H     NUMBER OF PIECES OF CROSS SECTION TO LARGE ,
     2     25H OR NO PIECES SPECIFIED  )
 79  FORMAT  (   48H     NUMBER OF POINTS ON CURVE MUST BE BETWEEN 2,
     2      7H AND  8)
 80  FORMAT  (   40H     SYMMETRY OPTION MUST BE 1 OR 0      )
 81  FORMAT  (/,5X,28HMATE CURVE NUMB SYMT (1=YES,,
     2      /,5X,29HRIAL NUMB  PTS  OPT   0 = NO/)
 82  FORMAT  ( 1X,A4, 3I5, 2E10.3, 8I5,/, 40X, 8I5 )
 83  FORMAT  (/6X,A4,3(I3,2X),///,6X,3HSIG,17X,8I5)
 84  FORMAT  (/,6X,3HEPS,17X,8I5)
 85  FORMAT  (/,5X, 3(I3,2X),/,7X,1HQ,17X,11I5)
 86  FORMAT  (/,7X,1HW,17X,11I5)
 87  FORMAT  (/,8X,2H- ,3(I3,2X),///,6X,3HSIG,17X,8I5)
 88  FORMAT  (/,5X,25HCURVE NUMB SYMT (1 = YES,,
     2      /,5X,26HNUMB  PTS  OPT,   0 = NO /)
 89  FORMAT  ( 5X, 3I5, 5X, 11I5, /, 25X, 11I5 )
 90  FORMAT  (   16H      AREA NUMBER, I5,   10H NOT INPUT)
 92  FORMAT  (   16H      AREA NUMBER,I5,   16H AND AREA NUMBER,I5,
     2           40H SHOULD HAVE THE SAME NUMBER OF PIECES  ,/,5X,
     3           45H SINCE THEY ARE BOTH ON MEMBERS OF STIFF TYPE,I5 )
 93  FORMAT  (   31H      STRESS-STRAIN CURVE NUMBER,I5,   10H NOT INPUT)
 95  FORMAT  (   32H      STRESS-STRAIN CURVE NUMBERS,I5,   4H AND,I5,
     2           36H SHOULD HAVE THE SAME NUMBER OF POINTS,/,5X,
     3           36H SINCE THEY ARE BOTH ON PIECE NUMBER,I5,
     4           16H OF AREA NUMBERS,I5,    4H AND,I5, /,5X,
     5           35H WHICH ARE ON MEMBERS OF STIFF TYPE ,I5  )
 96  FORMAT  (   13H PIECE NUMBER,I5,       15H ON AREA NUMBER,I5,
     2            4H AND,I5,      24H WHICH ARE ON STIFF TYPE,I5,/,5X,
     3           40H CANNOT BE BOTH A PIPE AND A RECTANGLE   )
 991 FORMAT  (   28H      MEMBER Q-W CURVE NUMBER,I5,10H NOT INPUT)
 993 FORMAT  (   29H      MEMBER Q-W CURVE NUMBERS,I5,4H AND,I5,
     2           38H SHOULD HAVE THE SAME NUMBER OF POINTS,/,5X,
     3           44H SINCE THEY ARE ON MEMBERS OF STIFFNESS TYPE,I5)
 994 FORMAT   (  27H STRESS-STRAIN CURVE NUMBER,I5, 16H ACTING ON PIECE,
     2 I5,       10H OF AREA  ,I5, 11H STIFF TYPE,I5,/,
     3           51H NOT INPUT WITH FINAL VALUES OF STRAIN IN ASCENDING,
     4           16H ALGEBRAIC ORDER )
 996 FORMAT (    49H      IF SYMMETRY OPTION = 1, FIRST POINT ON CURVE,
     2           21H      MUST EQUAL 0 - 0 )
 997 FORMAT (    32H      MEMBER SUPPORT CURVE NUMBER,I5,   9H ON STIFF,
     2            5H TYPE,I5,/, 35H      NOT INPUT WITH FINAL VALUES OF,
     3           43H DISPLACEMENTS IN ASCENDING ALGEBRAIC ORDER)
 101 FORMAT (5X,35H TOTAL NUMBER OF LAYERS IN X-SECT #,I5,/,5X,
     2           17H EXCEEDS LIMIT OF,I5,/,5X,
     3          30HNOTE : EACH PIPE HAS 10 LAYERS )
 103 FORMAT (5X,10HSTIFF TYPE,I4,17H AND PIECE NUMBER,I4,/,5X,
     2 49H HAVE DIFFERENT # OF LAYERS AT FROM AND TO JOINTS )
 104 FORMAT (5X,10HSTIFF TYPE,I4,12HPIECE NUMBER,I4,/,5X,
     2 58H MUST HAVE SAME SIG-EP CURVE # AT FROM AND TO JOINTS SINCE,
     3 10H INELASTIC)
 105 FORMAT (5X,10HSTIFF TYPE,I4,12HPIECE NUMBER,I4,/,5X,
     2 57H MUST HAVE SAME STRESS AND STRAIN MULTIPLIERS AT FROM AND,
     3 26H TO JOINTS SINCE INELASTIC)
 107 FORMAT (5X,12HCROSS-SECT #,I4,8H PIECE #,I4, 9H SIG-EP #,I4,/,5X,
     2           34H MUST BE SYMMETRIC SINCE INELASTIC )
 109 FORMAT (5X,12HCROSS-SECT #,I4,8H PIECE #,I4, 9H SIG-EP #,I4,/,5X,
     2 16HEXCEEDS LIMIT OF,I4,13H INPUT POINTS )
 120 FORMAT (5X,34HNUMBER OF ELEMENTS MUST BE > 4 & < ,I5)
 130 FORMAT (5X,26HALL MEMBERS WITH LOAD TYPE,I5,/,5X,
     2 51H MUST HAVE SAME # OF ELEMENTS FOR THEIR STIFF TYPES)
 140 FORMAT (5X,45HINVALID SIG-EP INPUT FOR X-SECT OF STIFF TYPE,I3,/,
     2 5X,35H ALPHA=0 AND BETA # 0 NOT PERMITTED )
 200 FORMAT (//,20H MOD OF      PRISMATIC,/,19H RIGIDITY  SHR.AREA,//)
 201 FORMAT (2E10.3)
 220 FORMAT (50H       NEGATIVE VALUES ARE NOT PERMITTED FOR A,I AND,
     2      12H SHEAR AREA )
 230 FORMAT (47H       IF INLOPT=1 PRISMATIC I AND A MUST BE 0.0 )
 240 FORMAT (45H       NUMBER OF CARDS IN THIS TABLE SHOULD BE,
     2      33H DIVIDED BY 3 TO USE SHEAR MODEL )
 241 FORMAT (//,7H MOD OF,/,9H RIGIDITY,//)
           DATA IBLNK /2H -/, MTNO /4H     /
           DATA SHEAR /5HSHEAR/
      PRINT 9
        IF (KEEP5A .EQ.0)  NSTL = 0
COMMENT - FRAME MUST HAVE AT LEAST ONE STIFFNESS TYPE
        IF (NCD5A .LE. 0 .AND. KEEP5A .LE. 0) GO TO 8300
        IF (NCD5A .NE. 0)  GO TO 1150
        IF (NST .LE. NSTL)  GO TO 8550
           NCR5 = 0
      PRINT 17
      PRINT 23
      GO TO 6100
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 1150       CONTINUE
            IF (KEEP5A .EQ. 1) GO TC 1240
 COMMENT - INITILIZE CONTROLS FOR ALL NEW DATA
            DO 1200  I=1,MNST
                  NC51(I) = -1
 1200             NCDS(I)= - 1
                  NC5 = 0
            GO TO 1250
 1240 PRINT 17
 1250       CONTINUE
        PRINT 14
                  NCR5 = 0
 COMMENT - DO FOR EACH STIFF TYPE
            DO 5900  JJ = 1,NST
 COMMENT - SKIP FOR STIFF TYPE PREVICUSLY DEFINED
            IF (NCDS(JJ) .NE. - 1) GO TC 5900
            IF (JJ .EQ. 1) GO TO 1300
            IF (JJ .EQ. NSTL + 1) GC TO 1300
 COMMENT - PRINT NEW HEADING FOR FIRST STIFF TYPE OF PROBLEM AND AFTER
 COMMENT - EVERY NON PRISMATIC STIFF TYPE
            IF (NCDS(JJ - 1) .GT. 0) PRINT 14
 1300       CONTINUE
            IF (NCR5 .EQ. NCD5A) GO TO 8560
 COMMENT - READ AND PRINT 1ST CARD FOR STIFF TYPE
      READ 12, ISTT,MSTT,E,ELEMNT,PRIT,PRAT,INLOPT,NCDST,IAXOPT,IOPOPT,
     2      IPINLT,IPINRT
            IF ( MSTT .EQ. 0 ) MSTT = MNE
      PRINT13, ISTT,MSTT,E,ELEMNT,PRIT,PRAT,INLOPT,NCDST,IAXCPT,IOPOPT,
     2      IPINLT,IPINRT
            IF ( MSTT .LT. 4 ) GO TC 9120
            IF ( MSTT .GT.MNE) GO TC 9120
            IF (IAXOPT .LT. 1  .OR. IAXOPT .GT. 2) GO TO 8580
            IF (NCDST .LT. 0) GO TO 8310
            IF (IOPOPT .LT. 0  .OR. IOPOPT .GT. 1) GO TO 8320
            IF (IPINLT .GT. 1) GO TC 8330
            IF (IPINRT .GT. 1) GO TC 8330
            IF (INLOPT .LT. 0 .OR. INLOPT .GT. 1) GO TO 8340
                  NCR5 = NCR5 + 1
            IF (JJ .NE. ISTT) GC TO 8650
            IF (ISTT .GT. NST) GO TC 8720
            IF (ISTT .LT. 0) GO TC 8710
 COMMENT - MULTIPLY A AND I BY E
                  PRFT = E*PRIT
                  PRAET = E*PRAT
            IF ( ISTT .EQ. 0 ) M = MNE
            IF ( ISTT .EQ. 0 ) GO TC 1350
                  MSTIF (ISTT) = MSTT
                  M = MSTT
 1350       CONTINUE
                  MP1 = M + 1
                  MP2 = M + 2
            IF ( ELEMNT .EQ. SHEAR ) GO TO 5200
            IF (NCDST .GT. 0) GO TO 2400
            IF (INLOPT .EQ. 1)  GO TO 8740
 COMMENT - PRISMATIC MEMBER - NC CARDS FOLLOW
            IF (PRFT .LE. 0.0  .OR. PRAET .LE. 0.0) GO TC 8660
 COMMENT - STORE TEMPORARY READ IN VALUES
                  PRF(ISTT) = PRFT
                  PRAE(ISTT) = PRAET
                  NCDS(ISTT) = 0
                  IAXCPS(ISTT) = IAXOPT
                  IOPOP(ISTT) = IOPOPT
                  IPINL(ISTT) = IPINLT
                  IPINR(ISTT) = IPINRT
                  INLOP(ISTT) = INLOPT
            GO TO 5900
 2400       CONTINUE
            IF (PRFT .GT. 0.0  .OR. PRAET .GT. 0.0) GO TO 8670
                  NCDS(ISTT) = NCDST
                  IAXOPS(ISTT) = IAXOPT
                  IOPOP(ISTT)  = IOPCPT
                  IPINL(ISTT) = IPINIT
                  IPINR(ISTT) = IPINRT
                  INLOP(ISTT) = INLOPT
            IF (INLOPT .EQ. 1) GO TC 5100
 COMMENT - NON PRISMATIC MEMBER - NCDST CARDS FOLLOW
 COMMENT - STORE TEMPORARY READ IN VALUES
        PRINT 18,ISTT
 COMMENT - DO FOR EACH ADDITIONAL DATA CARD FOR THIS STIFF TYPE
            DO 4500  II = 1,NCDST
                  NC5 = NC5 + 1
            IF (II .EQ. 1) NC51(ISTT) = NC5
            IF (NCR5 .EQ. NCD5A) GO TO 8560
 COMMENT - READ AND PRINT NON PRISMATIC STIFFNESS VALUES
      READ 15, XLS(NC5),XRS(NC5),FL(NC5),AEL(NC5),SXL(NC5),SYL(NC5),
     2      SZL(NC5)
      PRINT 16,XLS(NC5),XRS(NC5),FL(NC5),AEL(NC5),SXL(NC5),SYL(NC5),
     2      SZL(NC5)
                  NCR5 = NCR5 + 1
            IF (AEL(NC5) .LE. 0.0 .CR. FL(NC5) .LE. 0.0) GC TO 8660
 COMMENT - MULTIPLY A AND I BY E
                  FL(NC5) = E*FL(NC5)
                  AEL(NC5) = E*AEL(NC5)
 COMMENT - CHECK FOR BAD DATA
                  TH = ZLS(ISTT)/M
         IF   (II .EQ. 1) GO TO 3200
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      IF  (XLS(NC5) .NE. XRS(NC5 - 1)) GO TO 8540
      IF  (XLS(NC5) .NE. 0.0) GO TO 3300
      IF (XLS(NC5 - 1) + TH .GE. XRS(NC5) ) GO TO 8530
      GO TO 4000
 3200 IF (XLS(NC5) .NE. 0.0) GO TO 8510
 3300 IF (XRS(NC5) .EQ. 0.0) GO TC 4000
      IF (XLS(NC5) + TH .GE. XRS(NC5)) GO TO 8530
 4000 CONTINUE
 4500 CONTINUE
COMMENT - CHECK FOR STIFF NOT STOPING AT END OF MEMBER
          ERRLN =     (ZLS(ISTT) - XRS(NC5))
      IF (ERRLN .LT. 0.0) ERRLN = -ERRLN
      IF (ERRLN .GT. 0.1*TH) GO TO 8520
          XRS(NC5) = ZLS(ISTT)
      GO TO 5900
 5100 CONTINUE
COMMENT - INPUT NONLINEAR SUPPORT CURVE AND CROSS-SECTION NUMBERS
   READ  19, NAL(ISTT),NSXL(ISTT),NSYL(ISTT),NSZL(ISTT),NAR(ISTT),
     2 NSXR(ISTT),NSYR(ISTT),NSZR(ISTT),QM(ISTT),WM(ISTT)
          NCR5 = NCR5 + 1
   PRINT 20,ISTT,NAL(ISTT),NSXL(ISTT),NSYL(ISTT),NSZL(ISTT),
     2 NAR(ISTT),NSXR(ISTT),NSYR(ISTT),NSZR(ISTT),QM(ISTT),WM(ISTT)
      IF (NAL(ISTT) .LE. 0 .OR. NAR(ISTT) .LE. 0) GO TO 8350
      IF (NAL(ISTT) .GT. MNCS .OR. NAR(ISTT) .GT. MNCS) GO TO 8350
      IF (NSXL(ISTT) .LT. 0 .CR. NSXL(ISTT) .GT. MNQWM) GO TO 8750
      IF (NSYL(ISTT) .LT. 0 .OR. NSYL(ISTT) .GT. MNQWM) GO TO 8750
      IF (NSZL(ISTT) .LT. 0 .CR. NSZL(ISTT) .GT. MNQWM) GC TO 8750
      IF (NSXR(ISTT) .LT. 0 .OR. NSXR(ISTT) .GT. MNQWM) GC TO 8750
      IF (NSYR(ISTT) .LT. 0 .CR. NSYR(ISTT) .GT. MNQWM) GO TC 8750
      IF (NSZR(IS1T) .LT. 0 .OR. NSZR(ISTT) .GT. MNQWM) GO TO 8750
      GO TO 5900
 5200 CONTINUE
      IF (INLOPT .EQ.1 ) GO TC 5240
   PRINT 200
   READ 201, G,PRSHA
          NCR5 = NCR5 + 1
   PRINT201, G,PRSHA
          PRAGT = G*PRSHA
      IF ((PRFT .LE. 0.0 .OR. PRAET .LE. 0.0) .OR. PRAGT .LE. 0.0)
     2 GO TO 9220
COMMENT - STORE TEMPORARY READ IN VALUES
          PRF(ISTT) = PRFT
          PRAE(ISTT) = PRAET
          PRAG(ISTT) = PRAGT
          NCDS(ISTT) = 1
          IAXOPS(ISTT) = IAXCPT
          IOPOP(ISTT) = IOPOPT
          IPINL(ISTT) = IPINLT

          IPINR(ISTT) = IPINRT
          INLOP(ISTT) = INLOPT
          ELEMN(ISTT) = ELEMNT
      GO TO 5900
 5240 CONTINUE
      IF (PRFT .GT. 0.0 .OR. PRAET .GT. 0.0) GO TO 9230
          NCDS(ISTT) = NCDST
          IAXOPS(ISTT) = IAXCPT
          IOPOP(ISTT) = IOPOPT
          IPINL(ISTT) = IPINLT
          IPINR(ISTT) = IPINRT
          INLOP(ISTT) = INLOPT
          ELEMN(ISTT) = ELEMNT
COMMENT - INPUT NONLINEAR SUPPORT CURVE AND CROSS-SECTION NUMBERS
   READ  19, NAL(ISTT),NSXL(ISTT),NSYL(ISTT),NSZL(ISTT),NAR(ISTT),
     2 NSXR(ISTT),NSYR(ISTT),NSZR(ISTT),QM(ISTT),WM(ISTT)
          NCR5 = NCR5 + 1
   PRINT 20,ISTT,NAL(ISTT),NSXL(ISTT),NSYL(ISTT),NSZL(ISTT),
     2 NAR(ISTT),NSXR(ISTT),NSYR(ISTT),NSZR(ISTT),QM(ISTT),WM(ISTT)
      IF (NAL(ISTT) .LE. 0 .OR. NAR(ISTT) .LE. 0) GO TO 8350
      IF (NAL(ISTT) .GT. MNCS .OR. NAR(ISTT) .GT. MNCS) GC TO 8350
      IF (NSXL(ISTT) .LT. 0 .CR. NSXL(ISTT) .GT. MNQWM) GC TO 8750
      IF (NSYL(ISTT) .LT. 0 .CR. NSYL(ISTT) .GT. MNQWM). GC TO 8750
      IF (NSZL(ISTT) .LT. 0 .CR. NSZL(ISTT) .GT. MNQWM) GO TO 8750
      IF (NSXR(ISTT) .LT. 0 .CR. NSXR(ISTT) .GT. MNQWM) GC TO 8750
      IF (NSYR(ISTT) .LT. 0 .CR. NSYR(ISTT) .GT. MNQWM) GC TO 8750
      IF (NSZR(ISTT) .LT. 0 .CR. NSZR(ISTT) .GT. MNQWM) GC TO 8750
 5900 CONTINUE
      IF (NCR5 .LT. NCD5A) GC TC 8570
COMMENT - THE FOLLOWING STATEMENTS (UPTO STATEMENT 6000) SET  THE VALUES
COMMENT - FOR NUM OF ELEMENTS BY LOAD TYPE EQUAL TO THAT INPUT BY STIFF
COMMENT - TYPE; AND ALSO CHECKS FCR CONFLICT (SEE FORMAT 130 ABOVE)
      DO 5950 K = 1,NLT
 5950     NOTE(K) = 0
      DO 6000 JJ = 1,NM
          ISTT = IST(JJ)
          LTT  = LT (JJ)
      IF ( LTT  .EQ. 0 ) GO TC 6000
      IF ( ISTT .EQ. 0 ) GO TC 6000
      IF ( NOTE(LTT) .NE. 0 ) GO TC 5990
          NOTE(LTT) = 1
         MLOAD(LTT) = MSTIF(ISTT)
 5990 CONTINUE
      IF ( MLOAD(LTT) .EQ. MSTIF(ISTT) ) GO TO 6000
      GO TO 9130
 6000 CONTINUE
 6100 CONTINUE
COMMENT - INPUT TABLE 5B
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      PRINT 8
         IF (NCD5B .GT. 0 .OR. KEEP5B .GT. 0) GO TO 6170
         IF (INLOPT .EQ. 1) GO TO 8610
      PRINT 30
         GO TO 6900
 6170    CONTINUE
         IF (NCD5B .NE. 0) GO TO 6200
      PRINT 17
      PRINT 23
         GO TO 6900
 6200    IF (KEEP5B .EQ. 1) GO TO 6250
         DO 6220 I = 1,MNCS
 6220          NCDA(I) = -1
         GO TO 6275
 6250 PRINT 17
 6275 PRINT 41
      PRINT 43
 6300    CONTINUE
COMMENT - READ FIRST CARD OF TABLE 5B
      READ  42, NAT,NCDAT
               NCDA(NAT) = NCDAT
               NPCTOT (NAT) = 0
               NCR5 = NCR5 + 1
      PRINT 44, NAT,NCDA(NAT)
         IF (NAT .LE. 0 .OR. NAT .GT. MNCS) GO TO 8350
         IF (NCDAT .LE. 0 .OR. NCDAT .GT. MNPCS) GO TO 8780
COMMENT - DO FOR REMAINDER OF CARDS
         DO 6400 II = 1,NCDAT
      READ 45, NDIV(NAT,II),BI(NAT,II),DI(NAT,II),YI(NAT,II),
     2         IRECT(NAT,II),NSS(NAT,II),SM(NAT,II),EM(NAT,II),
     3         SHC(NAT,II)
               NCR5 = NCR5 + 1
         IF ( NDIV(NAT,II) .NE. 0 ) GO TO 6320
      PRINT 47,IBLNK,BI(NAT,II),DI(NAT,II),YI(NAT,II),IRECT(NAT,II),
     2         NSS(NAT,II),SM(NAT,II),EM(NAT,II),SHC(NAT,II)
               NPCTOT(NAT) = NPCTCT(NAT) + 1
      GO TO 6340
 6320    IF (IRECT(NAT,II) .EQ. 1 ) NDIV(NAT,II) = 10
      PRINT 46, NDIV(NAT,II),BI(NAT,II),DI(NAT,II),YI(NAT,II),
     2         IRECT(NAT,II),NSS(NAT,II),SM(NAT,II),EM(NAT,II),
     3         SHC(NAT,II)
               NPCTCT(NAT) = NPCTCT(NAT) + NDIV(NAT,II)
 6340 CONTINUE
         IF (IRECT(NAT,II) .NE. 1 .AND. IRECT(NAT,II) .NE. 0)
     2   GO TO 8760
         IF (NSS(NAT,II) .LE. 0 .OR. NSS(NAT,II) .GT. MNSS) GO TO 8770
 6400    CONTINUE
         IF ( NPCTCT(NAT) .GT. MNPCS ) GO TC 9101

         IF (NCR5 .LT. (NCD5A + NCD5B)) GO TO 6300
 6900    CONTINUE
COMMENT - INPUT TABLE 5C
      PRINT 7
         IF (NCD5C .GT. 0 .OR. KEEP5C .GT. 0) GO TO 7200
      PRINT 30
         GO TO 7500
 7200    IF (NCD5C .NE. 0) GO TO 7250
      PRINT 17
      PRINT 23
         GO TO 7500
 7250    IF (KEEP5C .EQ. 1) GO TO 7280
         DO 7270  I = 1,MNSS
 7270          NPTS(I) = -1
      GO TO 7300
 7280 PRINT 17
 7300    CONTINUE
         IF (ELEMNT .EQ. SHEAR) GO TO 7400
               NCD5C2 = NCD5C/2
         IF (NCD5C2*2 .NE. NCD5C  ) GO TO 8730
COMMENT - INPUT STRESS-STRAIN CURVE ON TWO CARDS
         DO 7350  II = 1,NCD5C2
      PRINT 81
      READ 82,MTRL,NC,NPTT,ISJT,ALPH,BET,(NSIT(I),I=1,8),(NEPT(I),I=1,8)
         DO 7310  I = 1, NPTT
               NSIG(NC,I) = NSIT(I)
               NEPS(NC,I) = NEPT(I)
 7310    CONTINUE
               NPTS(NC) = NPTT
               ISS(NC) = ISJT
               MATRL(NC) = MTRL
               ALPHA(NC) = ALPH
               BETA (NC) = BET
         IF ( MTRL .NE. MTNO ) GO TO 7315
      PRINT 87,        NC,NPTS(NC),ISS(NC), (NSIG(NC,I), I = 1,NPTT )
         GO TO 7317
 7315    CONTINUE
      PRINT 83, MTRL,NC,NPTS(NC),ISS(NC), (NSIG(NC,I), I = 1,NPTT )
 7317    CONTINUE
      PRINT 84,                          (NEPS(NC,I), I = 1,NPTT )
         IF (ISJT .EQ. 1 .AND. NSIT(1) .NE. 0) GC TC 8996
         IF (ISJT .EQ. 1 .AND. NEPT(1) .NE. 0) GO TO 8996
         IF (ISJT .NE. 1 .AND. ISJT .NE. 0) GO TO 8800
         IF (NPTT .LT. 2 .OR. NPTT .GT.  8) GO TO 8790
         IF (NC .LT.0 .OR. NC .GT. MNSS) GO TO 8770
COMMENT - SUBROUTINE  SECUR(NC) DEALS WITH STRESS-STRAIN CURVE NUMBER NC
COMMENT - AND ITS SUBDIVISIONING FOR PURPOSES OF INELASTIC TREATMENT
COMMENT - FOR THE PRESENT INELASTIC CASE IS RESTRICTED TO SYMMETRIC
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COMMENT - CURVES WITH NUMBER OF INPUT POINTS (OF THE SYMMETRY PART)
COMMENT - LESS THAN OR EQUAL TO  MSSINL ( = 4 AT PRESENT ) INCLUDING
COMMENT - ORIGIN (0,0)
C
COMMENT - SUBROUTINE SECUR ALSO DETERMINES THE IMPORTANT INFORMATIONS
COMMENT - FROM THE SPECIAL INPUT CURVE FOR MILD STEEL ( WITH VIRGIN
COMMENT - STRAIN HARDENING )
C
          IF (ISJT .EQ. 1 .AND. NPTT .LE. MSSINL ) GO TO 7320
      GO TO 7350
 7320     CONTINUE
COMMENT - SKIP CALLING SUBROUTINE SECUR FOR THE NONLINEAR ELASTIC
COMMENT - STRESS-STRAIN MODEL
          DO 7330 I = 1,MNCS
              NAT = I
              NCDAT = NCDA(NAT)
          IF (NCDAT .EQ. -1) GO TO 7330
          DO 7325 ITEMP = 1,NCDAT
          IF (NSS(NAT,ITEMP) .NE. NC) GO TO 7325
          IF (NDIV(NAT,ITEMP) .EQ. 0) GO TO 7325
      CALL      SECUR (NC,IABAN)
          GO TO 7350
 7325     CONTINUE
 7330     CONTINUE
 7350     CONTINUE
          GO TO 7500
 7400     CONTINUE
              NCD5C3 = NCD5C/3
          IF (NCD5C3*3 .NE. NCD5C  ) GO TO 9240
COMMENT - INPUT FLEXURAL STRESS-STRAIN CURVE AND SHEAR DATA IN 3 CARDS
          DO 7450  II = 1,NCD5C3
      PRINT 81
      READ 82,MTRL,NC,NPTT,ISJT,ALPH,BET,(NSIT(I),I=1,8),(NEPT(I),I=1,8)
          DO 7410  I = 1, NPTT
              NSIG(NC,I) = NSIT(I)
              NEPS(NC,I) = NEPT(I)
 7410     CONTINUE
              NPTS(NC) = NPTT
              ISS(NC) = ISJT
              MATRL(NC) = MTRL
              ALPHA(NC) = ALPH
              BETA (NC) = BET
          IF ( MTRL .NE. MTNO ) GO TO 7415
      PRINT 87,         NC,NPTS(NC),ISS(NC), (NSIG(NC,I), I = 1,NPTT )
          GO TO 7417
 7415     CONTINUE
      PRINT 83, MTRL,NC,NPTS(NC),ISS(NC), (NSIG(NC,I), I = 1,NPTT )
 7417     CONTINUE

      PRINT 84,                          (NEPS(NC,I), I = 1,NPTT )
      READ 201,GS(NC)
      PRINT 241
      PRINT 201,GS(NC)
          IF (ISJT .EQ. 1 .AND. NSIT(1) .NE. 0) GO TO 8996
          IF (ISJT .EQ. 1 .AND. NEPT(1) .NE. 0) GO TO 8996
          IF (ISJT .NE. 1 .AND. ISJT .NE. 0) GO TO 8800
          IF (NPTT .LT. 2 .OR. NPTT .GT.  8) GO TO 8790
          IF (NC .LT.0 .OR. NC .GT. MNSS) GO TO 8770
COMMENT - SUBROUTINE  SECUR(NC) DEALS WITH STRESS-STRAIN CURVE NUMBER NC
COMMENT - AND ITS SUBDIVISIONING FOR PURPOSES OF INELASTIC TREATMENT
COMMENT - FOR THE PRESENT INELASTIC CASE IS RESTRICTED TO SYMMETRIC
COMMENT - CURVES WITH NUMBER OF INPUT POINTS (OF THE SYMMETRY PART)
COMMENT - LESS THAN OR EQUAL TO  MSSINL ( = 4 AT PRESENT ) INCLUDING
COMMENT - ORIGIN (0,0)
COMMENT - SUBROUTINE SECUR ALSO DETERMINES THE IMPORTANT INFORMATIONS
COMMENT - FROM THE SPECIAL INPUT CURVE FOR MILD STEEL ( WITH VIRGIN
COMMENT - STRAIN HARDENING )
          IF (ISJT .EQ. 1 .AND. NPTT .LE. MSSINL ) GO TO 7420
      GO TO 7450
 7420     CONTINUE
COMMENT - SKIP CALLING SUBROUTINE SECUR FOR THE NONLINEAR ELASTIC
COMMENT - STRESS-STRAIN MODEL
          DO 7430 I = 1,MNCS
              NAT = I
              NCDAT = NCDA(NAT)
          IF (NCDAT .EQ. -1) GO TO 7430
          DO 7425 ITEMP = 1,NCDAT
          IF (NSS(NAT,ITEMP) .NE. NC) GO TO 7425
          IF (NDIV(NAT,ITEMP) .EQ. 0) GO TO 7425
      CALL      SECUR (NC,IABAN)
          GO TO 7450
 7425     CONTINUE
 7430     CONTINUE
 7450     CONTINUE
 7500     CONTINUE
COMMENT - INPUT TABLE 5D
      PRINT 6
          IF (NCD5D .GT. 0 .OR. KEEP5D .GT. 0) GO TO 7700
      PRINT 30
          GO TO 8000
 7700     IF (NCD5D .NE. 0) GO TO 7750
      PRINT 17
      PRINT 23
          GO TO 8000
 7750     IF (KEEP5D .EQ. 1) GO TO 7780
          DO 7770  I = 1,MNQWM
 7770         NPTM(I) = -1
```

```
               GO TO 7800
 7780 PRINT 17
 7800      CONTINUE
      PRINT 88
                 NCD5D2 = NCD5D/2
            IF (NCD5D2*2 .NE. NCD5D  ) GO TO 8730
COMMENT - INPUT MEMBER Q-W CURVE CN TWC CARDS
            DO 7850  II = 1,NCD5D2
      READ 89, NC,NPTT,ISJT,  (NQMT(I), I = 1,11),(NWMT(I), I = 1,11)
            DO 7810  I = 1,NPTT
                 NQM(NC,I) = NQMT(I)
                 NWM(NC,I) = NWMT(I)
 7810      CONTINUE
                 NPTM(NC) = NPTT
                 ISM(NC) = ISJT
      PRINT 85, NC,NPTM(NC),ISM(NC),  (NQM(NC,I), I = 1,NPTT)
      PRINT 86,  (NWM(NC,I), I = 1,NPTT)
            IF (ISJT .EQ. 1 .AND. NQMT(1) .NE. 0) GC TO 8996
            IF (ISJT .EQ. 1 .AND. NWMT(1) .NE. 0) GO TO 8996
            IF (ISJT .NE. 1 .AND. ISJT .NE. 0) GO TO 8800
            IF (NPTT .LT. 2 .OR. NPTT .GT. 11) GO TO 8790
            IF (NC .LT.0 .OR. NC .GT. MNQWM) GO TO 8750
 7850      CONTINUE
 8000      CONTINUE
COMMENT - CHECK FOR INCOMPATIBLE DATA CN CROSS-SECTION AND STRESS-STRAIN
COMMENT - CURVES ON SAME MEMBER
           DO 8100  I = 1,NST
                ISTT = I
           IF (INLOP (ISTT) .EQ. 0) GO TO 8100
                NALT = NAL(ISTT)
                NART = NAR(ISTT)
           IF (NCDA(NALT) .EQ. -1) GO TO 8900
           IF (NCDA(NART) .EQ. -1) GO TC 8910
           IF (NCDA(NALT) .NE. NCDA(NART)) GO TO 8920
                NCDAT = NCDA(NALT)
           DO 8050  K = 1,NCDAT
                KJ = K
                NSSLT = NSS(NALT,K)
                NSSRT = NSS(NART,K)
           IF (NPTS(NSSLT) .EQ. -1) GO TO 8930
           IF (NPTS(NSSRT) .EQ. -1) GO TC 8940
           IF (NPTS(NSSLT) .NE. NPTS(NSSRT)) GO TO 8950
           IF (IRECT(NALT,K) .NE. IRECT(NART,K)) GO TO 8960
                NPTT = NPTS(NSSLT)
           DO 8030  KK = 2,NPTT
           IF (EM(NALT,K)*(NEPS(NSSLT,KK) - NEPS(NSSLT,KK - 1)) .LE. 0.0)
     2     GO TO 8994
 8030      CONTINUE
                NPTT = NPTS(NSSRT)
           DO 8040  KK = 2,NPTT
           IF (EM(NART,K)*(NEPS(NSSRT,KK) - NEPS(NSSRT,KK - 1)) .LE. 0.0)
     2     GO TO 8995
 8040      CONTINUE
           IF (NDIV(NALT,K) .EQ. 0 .AND. NDIV(NART,K) .EQ. 0) GO TO 8050
COMMENT - THE FOLLOWING FOUR CHECKS APPLY ONLY FOR THE INELASTIC
COMMENT - STRESS-STRAIN CASE
           IF ( NDIV(NALT,K)  .NE.  NDIV(NART,K) )  GO TO 9103
           IF ( NSSLT         .NE.  NSSRT )         GO TC 9104
           IF ( SM(NALT,K)    .NE.  SM(NART,K) )    GO TO 9105
           IF ( EM(NALT,K)    .NE.  EM(NART,K) )    GC TO 9106
 8050      CONTINUE
 8100      CONTINUE
           IF ( NCD5B .EQ. 0 .OR. NCD5C .EQ. 0 ) GO TO 88104
COMMENT - CHECK FOR COMPLIANCE WITH THE SPECIAL (TEMPORARY) RESTRICTIONS
COMMENT - PLACED ON SIGMA-EPSILCN CURVES FOR THE INELASTIC CASE
           DO 8104 I = 1,MNCS
                NAT = I
                NCDAT = NCDA(NAT)
           IF ( NCDAT .EQ. -1 ) GC TO 8104
           DO 8102 II = 1,NCDAT
           IF ( NDIV(NAT,II) .EQ. 0 ) GC TO 8102
                NC = NSS(NAT,II)
                ISJT = ISS(NC)
                NPTT = NPTS(NC)
           IF ( ISJT .NE. 1 ) GO TC 9107
           IF ( NPTT .GT. MSSINL ) GO TO 9109
 8102 CCNTINUE
 8104 CONTINUE
88104      CONTINUE
COMMENT - CHECK FOR INCOMPATIBLE CATA ON MEMBER Q-W CURVES
           DO 8200  I = 1,NST
                ISTT = I
           IF (INLOP (ISTT) .EQ. 0) GO TO 8200
                K = 1
                NSLT = NSXL(ISTT)
                NSRT = NSXR(ISTT)
           GC TO 8120
 8105           K = 2
                NSLT = NSYL(ISTT)
                NSRT = NSYR(ISTT)
           GC TO 8120
 8110           K = 3
                NSLT = NSZL(ISTT)
                NSRT = NSZR(ISTT)
 8120      CONTINUE
           IF (NSLT .EQ. 0 .AND. NSRT .NE. 0) GO TO 8993
```

```
      IF (NSLT .EQ. 0) GO TO 8175
      IF (NPTM(NSLT) .EQ. -1) GO TO 8991
      IF (NPTM(NSRT) .EQ. -1) GO TO 8992
      IF (NPTM(NSLT) .NE. NPTM(NSRT)) GO TO 8993
          NPTT = NPTM(NSLT)
      DO 8160  II = 2,NPTT
      IF (WM(ISTT)*(NWM(NSLT,II) - NWM(NSLT,II - 1)) .LE. 0.0)
     2GO TO 8997
8160  CONTINUE
          NPTT = NPTM(NSRT)
      DO 8170  II = 2,NPTT
      IF (WM(ISTT)*(NWM(NSRT,II) - NWM(NSRT,II - 1)) .LE. 0.0)
     2GO TO 8998
8170  CONTINUE
8175  CONTINUE
      GO TO (8105,8110,8200),K
8200  CONTINUE
      GO TO 9900
8300 PRINT 30
      GO TO 9700
8310 PRINT 31
      GO TO 9700
8320 PRINT 32
      GO TO 9700
8330 PRINT 33
      GO TO 9700
8340 PRINT 34
      GO TO 9700
8350 PRINT 35
      GO TO 9700
8510 PRINT 51
      GO TO 9700
8520 PRINT 52
      GO TO 9700
8530 PRINT 53
      GO TO 9700
8540 PRINT 54
      GO TO 9700
8550 PRINT 55
      GO TO 9700
8560 PRINT 56
      GO TO 9700
8570 PRINT 57
      GO TO 9700
8580 PRINT 58
      GO TO 9700
8610 PRINT 61
      GO TO 9700
8650 PRINT 65
      GO TO 9700
8660 PRINT 60
      GO TO 9700
8670 PRINT 67
      GO TO 9700
8710 PRINT 71
      GO TO 9700
8720 PRINT 72
      GO TO 9700
8730 PRINT 73
      GO TO 9700
8740 PRINT 74
      GO TO 9700
8750 PRINT 75
      GO TO 9700
8760 PRINT 76
      GO TO 9700
8770 PRINT 77
      GO TO 9700
8780 PRINT 78
      GO TO 9700
8790 PRINT 79
      GO TO 9700
8800 PRINT 80
      GO TO 9700
8900 PRINT 90, NALT
      GO TO 9700
8910 PRINT 90, NART
      GO TO 9700
8920 PRINT 92, NALT, NART, ISTT
      GO TO 9700
8930 PRINT 93, NSSLT
      GO TO 9700
8940 PRINT 93, NSSRT
      GO TO 9700
8950 PRINT 95, NSSLT, NSSRT,KJ, NALT, NART, ISTT
      GO TO 9700
8960 PRINT 96,KJ, NALT, NART, ISTT
      GO TO 9700
8991 PRINT 991, NSLT
      GO TO 9700
8992 PRINT 991, NSRT
      GO TO 9700
8993 PRINT 993, NSLT, NSRT, ISTT
      GO TO 9700
8994 PRINT 994, NSSLT,KJ, NALT, ISTT
      GO TO 9700
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8995 PRINT 994, NSSRT,KJ, NART, ISTT
        GO TO 9700
8996       PRINT 996
        GO TO 9700
8997 PRINT 997, NSLT,ISTT
        GO TO 9700
8998 PRINT 997, NSRT,ISTT
     GO TO 9700
9101 PRINT 101, NAT, MNPCS
     GO TO 9700
9103 PRINT 103, ISTT, K
     GO TO 9700
9104 PRINT 104, ISTT,K
     GO TO 9700
9105 PRINT 105, ISTT,K
     GO TO 9700
9106 PRINT 105,ISTT,K
     GO TO 9700
9107 PRINT 107, NAT, II, NC
     GO TO 9700
9109 PRINT 109,NAT,II,NC,MSSINL
        GO TO 9700
9120 PRINT 120, MNE
        GO TO 9700
9130 PRINT 130, LTT
        GO TO 9700
9220 PRINT 220
        GO TO 9700
9230 PRINT 230
        GO TO 9700
9240 PRINT 240
9700           IABAN = 1
9900      CONTINUE
               NSTL = NST
          IF ( IABAN .EQ. 1 ) GO TO 13000
COMMENT - IDENTIFY THE VARIOUS CATEGORIES OF STIFFNESS TYPES AS FOLLOW
C              (->  -2  LINEAR
C              (    -1  NONLINEAR ELASTIC
C         MODEL (    0  MASING                               ALPHA=0,BETA=0
C              (     1  MASING + DEGRADATION                 ALPHA#0,BETA=0
C              (->   2  MILD STEEL,DEGRADE+YIELD GROWTH;     ALPHA#0,BETA#0
C         IN A HYBRID CROSS SECTION, STIFFNESS TYPE  WILL BE
C         DETERMINED AS THE HIGHEST AMONG THE POSSIBLE TYPES FOR THAT
C         CROSS SECTION
          DO 12000 I = 1,NST
               ISTT = I
               MODEL(ISTT) = -2
          IF ( INLOP(ISTT) .EQ. 0 ) GO TO 12000

               NAT    = NAL(ISTT)
               NCDAT  = NCDA(NAT)
               MODEL(ISTT) = -1
               NTEMP  = 0
               TEMPA  = 0.0
               TEMPB  = 0.0
          DO 11000 K = 1,NCDAT
               NC     = NSS(NAT,K)
               NTEMP  = NTEMP  + NDIV(NAT,K)
               TEMPA  = TEMPA  + ALPHA(NC)
               TEMPB  = TEMPB  + BETA (NC)
11000     CONTINUE
          IF ( NTEMP  .EQ. 0 ) GO TO 12000
          IF ( TEMPA+TEMPB .GT. 1.0D-15) GO TO 11200
               MODEL(ISTT) = 0
          GO TO 12000
11200     CONTINUE
          IF ( TEMPB  .GT. 1.0D-10 ) GO TO 11400
               MODEL(ISTT) = 1
          GO TO 12000
11400     CONTINUE
          IF ( TEMPA  .GT. 1.0D-10 ) GO TO 11600
               IABAN = 1
      PRINT 140, ISTT
          GO TO 12000
11600     CONTINUE
               MODEL(ISTT) = 2
12000     CONTINUE
13000     CONTINUE
      RETURN
      END
```

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*********************************** SUBROUTINE ***********************************
      SUBROUTINE SECUR ( NC, IABAN )
COMMENT - SUBROUTINE SECUR DEALS WITH THE DECOMPOSITION OF THE
COMMENT - BASIC INPUT INTEGER CURVE NUMBER NC .
COMMENT - (FOR THE SPECIAL CASE OF MILD STEEL, ONLY ONE COMPONENT IS
COMMENT - USED, TOGETHER WITH THE FEATURES OF VIRGIN STRAIN HARDENING
COMMENT - DEGRADATION, AND YIELD GROWTH)
COMMENT - PROPER SCALE FACTORS ARE TAKEN CARE OF IN SUBROUTINE  FAEREV
COMMENT - THREE TYPES OF INELASTIC STRESS-STRAIN CURVES ARE POSSIBLE
COMMENT - MASING MODEL                ( ALPHA = 0 , BETA = 0 )
COMMENT - MASING WITH DEGRADATION     ( ALPHA # 0 , BETA = 0 )
COMMENT - SPECIAL FOR MILD STEEL      ( ALPHA # 0 , BETA # 0 )
COMMENT - FOR THE PRESENT, INELASTIC CASE IS RESTRICTED TO SYMMETRIC
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C          CURVES WITH THE NUMBER OF INPUT POINTS LESS THAN OR EQUAL TO
C          4 ( = MSSINL ) INCLUDING ORIGIN (0,0)
COMMENT - DESCENDING BRANCHES ARE NOT CONSIDERED AND HENCE MUST NOT
C          BE INPUT
COMMENT - NO LIMIT IS PUT ON MAXIMUM STRAIN
      IMPLICIT REAL * 8 (A-H , O-Z)
      DIMENSION QQ(11), WW(11), RMAX(10)
      COMMON /BLOC13/ NPTS( 08),    ISS( 08),  NSIG(08,11),NEPS(08,11),
     2     NSIT(11),     NEPT(11)
      COMMON /SKT12/       EPSIEL(08,03), SIGMAX(08,03)
      COMMON /SKT31/ ALPHA (8), BETA  (8), SMLSLP(8), EPSTHD(8),
     2               SLOPHD(8), SIGULT(8), MATRL (8)
    2 FORMAT ( 10X, 4 ( F11.4, 4X ) )
    9 FORMAT ( / )
   90 FORMAT (10X,37HDETAILS OF BASIC STRESS-STRAIN CURVES,/,10X,
     2          24HSCALING FACTORS EXCLUCED,/)
  100 FORMAT (10X,14HCURVE NUMBER =,I4,5X,25H # OF COMPONENT SPRINGS =,
     2 I4)
  102 FORMAT (10X, 9H  STRAINS,6X,9H STRESSES,6X,12HSTIFFNESS OF,3X,
     2 13HMAX STRESS OF,/,
     3 10X,5HINPUT,10X,5HINPUT,10X,10HCOMPONENTS,8X,10HCOMPONENTS,/,
     4 10X,10H(INTEGERS),4X,10H(INTEGERS),5X,10H(UNSCALED),6X,
     5      10H(UNSCALED),/)
  103 FORMAT (//,5X,  25HDEGRADATION  YIELD GROWTH,/,
     2          9X,   5HALPHA,8X,4HBETA,//,5X,2(F10.4 ,3X),//)
  104 FORMAT (//,5X,43HDEGRADATION DEGRADATION  YIELD GROWTH YIELD,
     2 7H GROWTH,  49H SMALL SLOPE    EPSILON        SLOPE      ULTIMATE,
     3/,9X,5HALPHA,8X,5HALPHA,8X,4HBETA,9X,4HBETA,6X,11HFROM YLD PT,
     4 36H  STRAIN HRD   STRAIN HRD     STRESS,/,
     5  8X, 47H(INPUT)     (COMPUTED)      (INPUT)    (COMPUTED),/)
  105 FORMAT (//,5X,2(F10.4,9X,1H-,6X), 4(F10.4,3X),//)
  106 FORMAT (//,5X,F10.4,9X,1H-,12X,1H-,6X,5(F10.4,3X),//)
  107 FORMAT (//,11X,1H-,6X,2(F10.4,3X),6X,1H-,6X,4(F10.4,3X),/)
  108 FORMAT (//,11X,1H-,6X,F10.4,9X,1H-,6X,5(F10.4,3X),//)
  120 FORMAT (//,33H ERROR IN INPUT OF SIG-EP CURVE #,I3,/,
     2 47H BETA FACTOR MUST = 0 UNLESS MATERIAL IS "MILD")
  122 FORMAT (//,33H ERROR IN INPUT OF SIG-EP CURVE #,I3,/,
     2 59H DEGRADATION ALGORITHM (ALPHA # 0) DEFINED ONLY IF CURVE IS,
     3 20H CONTINUOUSLY CONVEX,/,20H (EXCEPT FOR "MILD"))
  124 FORMAT (//,25H **** WARNING FOR CURVE #,I3,5H ****,/,
     2 61H MASING MODEL WITH CURVE NOT CONTINUOUSLY CONVEX IS PERMITTED,
     3 14H AT USERS RISK )
  126 FORMAT (//,33H ERROR IN INPUT OF SIG-EP CURVE #,I3,/,
     2 40H 4 POINTS MUST BE USED FOR "MILD" CURVE )
  130 FORMAT (//,5X,28H ALPHA MUST BE BETWEEN 0 & 1 )
  132 FORMAT (//,5X,34H****WARNING : ALPHA SEEMS HIGH****,//)
  134 FORMAT (//,5X,18H BETA MUST BE > 0 )
  136 FORMAT (//,5X,37H***WARNING : BETA SEEMS VERY HIGH****,//)
  138 FORMAT (//,5X,47HSLOPE FOLLOWING YIELD POINT MUST BE EITHER ZERO,
     2 47H OR A NOMINALLY SMALL POSITIVE VALUE FOR "MILD",//)
            DATA MILD /4HMILD/
            NAGAIN = 0
  180     CONTINUE
            NPT = NPTS(NC)
          DO 190 J = 1,NPT
            QQ (J) = NSIG (NC,J)
            WW (J) = NEPS (NC,J)
  190     CONTINUE
            NPTM2 = NPT - 2
            NPTM1 = NPT - 1
          IF ( NPTM2 .EQ. 0 ) GO TO 205
          DO 200 J = 1,NPTM2
            SLOK=(QQ(J+1)-QQ(J))/(WW(J+1)-WW(J))
           SLOKP1=(QQ(J+2)-QQ(J+1))/(WW(J+2)-WW(J+1))
            STF  =SLOK - SLOKP1
           RMAX(J)=WW(J+1) * STF
  200 CONTINUE
  205 CONTINUE
            STF          =  (QQ(NPT)-QQ(NPTM1))/(WW(NPT)-WW(NPTM1) )
            RMAX(NPTM1)= WW(NPT) * STF
          IF ( MATRL(NC) .EQ. MILD ) GO TO 400
          IF ( BETA (NC) .LT. 1.0D-10) GO TO 300
            IABAN = 1
      PRINT 120, NC
          GO TO 1000
  300     CONTINUE
          DO 350 J = 1,NPTM1
          IF ( RMAX(J) .GE. 0.0 ) GO TO 350
          GO TO 370
  350     CONTINUE
          GO TO 390
  370     CONTINUE
          IF ( ALPHA (NC) .LT. 1.0D-10 ) GO TO 380
            IABAN = 1
      PRINT 122, NC
          GO TO 1000
  380     CONTINUE
      PRINT 124, NC
  390     CONTINUE
            SMLSLP(NC) = 0.0
            EPSTHD(NC) = 10000.0 * WW(2)
            SLOPHD(NC) = 0.0
            SIGULT(NC) = QQ(NPT)
          GO TO 500
  400     CONTINUE
          IF ( NPT .EQ. 4 ) GO TO 410
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```
         IF ( NAGAIN .EQ. 1 ) GO TO 500
              IABAN = 1
     PRINT 126, NC
         GO TO 1000
  410    CONTINUE
              NTEMPA = 1
              NTEMPB = 1
         IF ( ALPHA (NC) .GT. 1.0D-10 ) GO TO 420
COMMENT - IF ALPHA IS NOT INPUT FOR MILD(STEEL), USE A REASONABLE VALUE
              ALPHA (NC) = 0.1
              NTEMPA = 0
  420    CONTINUE
         IF ( BETA  (NC) .GT. 1.0D-10 ) GO TO 440
COMMENT - IF BETA  IS NOT INPUT FOR MILD(STEEL), THEN IT IS TAKEN
COMMENT - AS ZERO. HOWEVER IT IS OUTPUT UNDER THE 'COMPUTED' TITLE.
              BETA(NC) = 0.0
              NTEMPB = 0
  440    CONTINUE
              SMLSLP(NC) = ( QQ(3)-QQ(2) ) / ( WW(3)-WW(2) )
              EPSTHD(NC) = WW(3)
              SLOPHD(NC) = ( QQ(4)-QQ(3) ) / ( WW(4)-WW(3) )
              SIGULT(NC) = QQ(4)
              NPTS  (NC) = 2
              NAGAIN     = 1
         GO TO 180
  500    CONTINUE
     PRINT 9
     PRINT 90
     PRINT 100, NC, NPTM1
     PRINT 9
     PRINT 102
     PRINT 2, WW(1), QQ(1)
         DO 800 J = 2,NPT
              STF = RMAX(J-1) / WW(J)
     PRINT 2, WW(J), QQ(J), STF, RMAX(J-1)
  800    CONTINUE
         DO 900 J = 1,NPTM1
COMMENT - EPSIEL(NC,J) AND SIGMAX(NC,J) PERTAIN TO THE JTH COMPONENT
C        OF THE BASIC INTEGER INPUT CURVE NUMBER  NC
              EPSIEL  ( NC,J) =    WW(J+1)
              SIGMAX  (NC,J) = RMAX(J)
  900    CONTINUE
         IF ( MATRL (NC) .EQ. MILD ) GO TO 950
     PRINT 103, ALPHA(NC), BETA(NC)
         GO TO 982
  950    CONTINUE
     PRINT 104
         IF ( NTEMPA + NTEMPB .EQ. 0 )              GO TO 980
         IF ( NTEMPA .EQ. 0 .AND. NTEMPB .NE. 0 ) GO TO 970
         IF ( NTEMPA .NE. 0 .AND. NTEMPB .EQ. 0 ) GO TO 960
     PRINT 105, ALPHA(NC),BETA(NC),SMLSLP(NC),EPSTHD(NC),SLOPHD(NC),
    2         SIGULT(NC)
         GO TO 982
  960 PRINT 106, ALPHA(NC),BETA(NC),SMLSLP(NC),EPSTHD(NC),SLOPHD(NC),
    2         SIGULT(NC)
         GO TO 982
  970 PRINT 107, ALPHA(NC),BETA(NC),SMLSLP(NC),EPSTHD(NC),SLOPHD(NC),
    2         SIGULT(NC)
         GO TO 982
  980 PRINT 108, ALPHA(NC),BETA(NC),SMLSLP(NC),EPSTHD(NC),SLOPHD(NC),
    2         SIGULT(NC)
  982    CONTINUE
         IF ( ALPHA(NC) .GE. 0.0 .AND. ALPHA(NC) .LE. 1.0 ) GO TO 984
              IABAN = 1
     PRINT 130
         GO TO 1000
  984    CONTINUE
         IF ( MATRL(NC) .NE. MILD ) GO TO 985
         IF ( ALPHA(NC) .LT. 0.35) GO TO 985
     PRINT 132
  985    CONTINUE
         IF ( BETA(NC) .GE. 0.0 ) GO TO 986
              IABAN = 1
     PRINT 134
         GO TO 1000
  986    CONTINUE
         IF ( MATRL(NC) .NE. MILD ) GO TO 987
         IF ( BETA(NC) .LE. 0.8 ) GO TO 987
     PRINT 136
  987    CONTINUE
         IF ( SMLSLP(NC) .GE. 0.0 ) GO TO 1000
              IABAN = 1
     PRINT 138
 1000    CONTINUE
     RETURN
     END


********************************** SUBROUTINE **********************************
     SUBROUTINE RDMLD
COMMENT - SUBROUTINE RDMLD  INPUTS MEMBER LOAD DATA (TABLE 6) CHECKS
COMMENT - FOR BAD DATA, CONVERTS LOADS AND DISTANCES TO MEMBER
COMMENT - COORDINATES AND ECHO PRINTS DATA
      IMPLICIT REAL*8 (A-H,O-Z)
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      COMMON /BLOCK3/ DXL( 25),    DYL( 25),    ZLL( 25),    DC1L( 25),
     2     DC2L( 25),   UQX( 25),    UQY( 25),    NCDL( 25),   IAXOPL( 25),
     3     NC61( 25),   IOVRM(25)
      COMMON /BLOCK6/ XLL( 75),    XRL( 75),    QXL( 75),    QYL( 75),
     2     QZL( 75),    IOVRL(75)
      COMMON /BLK1/  TOL,    ELEMNT,NJST,   KEEP3C,NCD3C,
     2           KEEP2, KEEP3A,KEEP3B,KEEP4A,KEEP4B,KEEP4C,KEEP5A,
     3           KEEP5B,KEEP5C,KEEP5D,KEEP6, KEEP7, NCD2,  NCD3A,
     4           NCD3B, NCD4A, NCD4B, NCD4C, NCD5A, NCD5B, NCD5C,
     5           NCD5D, NCD6,  NCD7,  IP8,   IP9,   IP10,  ITYPE,
     6           IABAN, IFORM, NM,    NJT,   NST,   NLT,   M,
     7           MP1,   MP2,   ISTT,  LTT,   ITYPEL,IDJ,   NSTL
      COMMON /BLK3/ MNJT,MNST,MNLT,MNM,MNC5,MNC6,MDJT,MNJS,MNE,MNCS,
     2     MNPCS,MNSS,MNOWM,MNJST,MNJSS
      COMMON /BLK8/ NLTL
      COMMON / BR / PCRML, PCRJL, NLR, NLRA
      COMMON /SKT30/ MSTIF(25), MLOAD(25), MODEL(25)
    9 FORMAT (   40H      TABLE 6 - MEMBER LOAD DATA             ,///)
   10 FORMAT (   49H      LOAD TYPES INCREASED BY PERCENTAGE OVER LAST,
     2        10H PROBLEM   ,//,5X,15H LOAD   PERCENT ,/,5X,
     3                       15H TYPE    CHANGE ,//)
   12 FORMAT ( 5X, I5, 20X, 2E10.3,  5X,2I5, 14X, A1 )
   13 FORMAT ( 5X, I5,      2E11.3,     2I5, 14X, A1 )
   14 FORMAT (//,50H       LOAD  UNIFORM    UNIFORM     NO   AXIS      ,
     2        /, 50H       TYPE      QX           QY     CARDS  OPT     ,
     3        //)
   15 FORMAT (10X,5E10.3,19X,A1)
   16 FORMAT ( 5X,5E11.3,14X,A1)
   17 FORMAT (   48H      HOLDING DATA FROM THE PREVIOUS PROBLEM PLUS,
     2        15H THE FOLLOWING ,//)
   18 FORMAT (//,20H            LOAD TYPE ,I5,6H CONTD,/,2X,
     2        49H         FROM          TO           QX          QY       ,
     3        30H        QZ                  ,//)
   19 FORMAT (4X,50H**** LOAD REDUCTION PROBLEM - MEMBER LOADS REDUCES,
     2  F5.2,28H PER CENT BELOW LAST PROBLEM,20(1H*),I5,
     3  16H LOAD REDUCTIONS )
   21 FORMAT ( 5X,I5,E10.3,A4,A1)
   22 FORMAT ( 5X,I5,E11.3,1X,A4,A1)
   23 FORMAT (   10H      NONE )
   24 FORMAT (   20H      NO DATA         )
   52 FORMAT (   50H      LOAD SPECIFIED BEYOND THE END OF MEMBER        )
   53 FORMAT (   50H      LOAD SEQUENCE MUST BE LONGER THAN 1/M *SPAN    )
   54 FORMAT (   51H      LOAD SPECIFIED AT NEGATIVE DISTANCE ALONG MEMB)
   55 FORMAT (   49H      TO DISTANCE OF ZERO IMPLIES THAT IT IS FIRST,
     2  55H CARD OF TWO CARD SEQUENCE AND NEXT CARD WILL HAVE FROM,/,
     3  20H DISTANCE OF ZERO   )
   56 FORMAT (   50H      ALL CARDS SPECIFIED FOR TABLE 6 READ BUT ALL ,
     2        25HLOAD TYPES NOT SPECIFIED ,/,
     3        46H      CHECK CARD COUNT AND NUMBER OF LOAD TYPES)
   57 FORMAT (   48H      NO CARDS IN TABLE 6  BUT ALL LOAD TYPES NOT,
     2        10H SPECIFIED)
   58 FORMAT (   51H      ALL LOAD TYPES SPECIFIED BUT ALL CADS NOT READ
     2   ,/,  46H      CHECK CARD COUNT AND NUMBER OF LOAD TYPES)
   59 FORMAT (   40H      AXIS OPTION MUST BE 1,2,3, OR 4     )
   60 FORMAT (   51H      NUMBER OF CARDS TO FOLLOW MUST NOT BE NEGATIVE)
   61 FORMAT (   48H      CONCENTRATED LOADS AT 0.0 ARE NOT PERMITTED)
   62 FORMAT (   50H      LOADS CAN NOT BE INCREASED IF NO LOADS HELD  )
   65 FORMAT (   45H      LOAD TYPES MUST BE IN ASCENDING ORDER    )
   67 FORMAT (   50H      IF 2ND CARD USED FOR LOAD TYPE, UNIFORM LOAD ,
     2        20HVALUES MUST BE 0.0  )
   71 FORMAT (   36H      LOAD TYPES MUST NOT BE NEGATIVE)
   72 FORMAT (   48H      LOAD TYPE GREATER THAN TOTAL NUMBER OF LOAD,
     2        16H TYPES SPECIFIED)
   73 FORMAT (//,51H ALL REMAINING LOAD TYPES INCREASED BY SAME PERCENT,
     2   /)
      DIMENSION DITTO (2)
            DATA IIOVER /1H*/, DITT /4HDITT/
COMMENT - CHECK FOR LOAD REDUCTION
         IF ( NLR .EQ. 0 ) GO TO 1020
            FAC = 1.0 - PCRML / 100.0
            NC6 = 0
         IF ( NLT .EQ. 0 ) GO TO 9900
         DO 1010 LTT = 1,NLT
            NCDLT = NCDL (LTT)
         IF ( NCDLT .EQ. 0 ) GO TO 1008
         DO 1005 II = 1,NCDLT
            NC6 = NC6 + 1
         IF ( IOVRL(NC6) .EQ. IIOVER ) GO TO 1005
            QXL(NC6) = QXL(NC6) * FAC
            QYL(NC6) = QYL(NC6) * FAC
            QZL(NC6) = QZL(NC6) * FAC
 1005    CONTINUE
         GO TO 1010
 1008    CONTINUE
         IF ( IOVRM(LTT) .EQ. IIOVER ) GO TO 1010
            UQX (LTT) = UQX (LTT) * FAC
            UQY (LTT) = UQY (LTT) * FAC
 1010    CONTINUE
      PRINT 19, PCRML, NLR
         GO TO 9900
 1020    CONTINUE
COMMENT - PRINT TABLE HEADING
      PRINT 9
         IF (KEEP6 .NE. 2) GO TO 1101
         IF (NLTL .EQ. 0) GO TO 8620
      PRINT 17
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            NC6 = 0
            NCR6 = 0
COMMENT - DO FOR EACH OLD LOAD TYPE
          DO 1080 JJ = 1,NLTL
          IF ( JJ .EQ. 1 ) GO TO 1025
          IF (DITTO(1).EQ.DITT ) GO TO 1027
 1025     CONTINUE
          IF (NCR6 .EQ. NCD6) GO TO 8560
      PRINT 10
COMMENT - READ LOAD TYPE AND PERCENT INCREASE
      READ 21, LTT, PER, DITTO
      PRINT22, LTT, PER, DITTO
          IF ( DITTO(1) .EQ. DITT ) PRINT 73
            NCR6 = NCR6 + 1
          IF (JJ .NE. LTT) GO TO 8650
 1027       LTT = JJ
            FAC = 1.0 + PER/100.0
            NCDLT = NCDL(LTT)
          IF (NCDLT .EQ. 0) GO TO 1040
COMMENT - INCREASE GENERAL LOADS
          DO 1030 II = 1,NCDLT
            NC6 = NC6 + 1
          IF ( IOVRL(NC6) .EQ. IICVER ) GO TO 1030
            QXL(NC6) = QXL(NC6)*FAC
            QYL(NC6) = QYL(NC6)*FAC
            QZL(NC6) = QZL(NC6)*FAC
 1030     CONTINUE
          GO TO 1080
 1040     CONTINUE
COMMENT - INCREASE UNIFORM LOADS
          IF ( IOVRM(LTT) .EQ. IIOVER ) GO TO 1080
            UQX(LTT) = UQX(LTT)*FAC
            UQY(LTT) = UQY(LTT)*FAC
 1080     CONTINUE
          IF  (NLT .NE. NLTL) GO TO 1260
          IF  (NCR6 .LT. NCD6) GO TO 8580
          GO TO 9900
 1101     IF (KEEP6 .EQ. 0) NLTL = 0
          IF (NCD6 .EQ. 0 .AND. KEEP6 .EQ. 0) GO TO 1110
          GO TO 1120
 1110 PRINT 24
          IF (NLT .NE. 0) GO TO 8570
          GO TO 9900
 1120     IF (NCD6 .NE. 0) GO TO 1150
          IF (NLT .NE. NLTL) GO TC 8570
      PRINT 17
      PRINT 23
          GO TO 9900
 1150     CONTINUE
          IF (KEEP6 .EQ. 1) GO TO 1240
COMMENT - INITILIZE CCNTROL CCNSTANTS
 1160     DO 1200  I = 1,MNLT
            NC61(I) = -1
 1200       NCDL(I)= - 1
            NC6 = 0
          GO TO 1250
 1240 PRINT 17
          IF (NLTL .EQ. 0) GO TO 1160
 1250     CONTINUE
            NCR6 = 0
 1260     CONTINUE
      PRINT 14
COMMENT - DO FOR EACH LOAD TYPE
            DO 4900 JJ =1,NLT
COMMENT - SKIP FOR LOAD TYPES HELD FRCM PREVIOUS PROBLEM
        IF (NCDL(JJ) .NE. -1) GO TO 4900
          IF (JJ .EQ. 1) GO TO 1300
          IF (JJ .EQ. NLTL + 1) GC TO 1300
          IF (NCDL(JJ - 1) .GT. 0) PRINT 14
 1300     CONTINUE
          IF (NCR6 .EQ. NCD6) GO TO 8560
COMMENT - READ AND PRINT FIRST CARD FOR LOAD TYPE
      READ  12, LTT,UQXT,UQYT,NCDIT,IAXOPT,IOVERT
      PRINT 13, LTT,UQXT,UQYT,NCDIT,IAXOPT,IOVERT
          IF (IAXOPT .LT.1  .OR. IAXOPT .GT. 4) GO TO 8590
            NCR6 = NCR6 + 1
          IF (LTT .GT. NLT) GO TO 8720
          IF ( LTT .LT. 0) GO TO 8710
          IF (JJ .NE.  LTT) GO TC 8650
          IF (NCDLT .LT. 0) GO TC 8600
          IF ( LTT .EQ. 0 ) GO TO 1350
            M = MLOAD ( LTT)
            MP1 = M+1
            MP2 = M+2
 1350     CONTINUE
          IF (NCDLT .GT. 0) GO TC 2400
COMMENT - UNIFORM LOADS ONLY
          IF (IAXOPT .EQ. 1) GO TC 1500
          IF (IAXOPT .EQ. 2) GO TC 1400
COMMENT - AXIS OPTICN 3 OR 4 - CCNVERT UNIFORM LOADS TO DIRECTIONS
COMMENT - AND INTENSITY OF MEMBER AXES
            TEMP1 = DC1L(LTT)
            TEMP2 = DC2L(LTT)
          IF ( TEMP1 .LT. 0.0) TEMP1 = - TEMP1
          IF ( TEMP2 .LT. 0.0) TEMP2 = - TEMP2
            UQX(LTT) =  UQXT*DC1L(LTT)*TEMP2 +
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     2            UQYT*DC2L(LTT)*TEMP1
            UQY(LTT)  = -UQXT*DC2L(LTT)*TEMP2 +
     2                   UQYT*DC1L(LTT)*TEMP1
         GO TO 1600
COMMENT - AXIS OPTION 2 - CONVERT UNIFORM LOADS TO DIRECTIONS OF
COMMENT - MEMBER AXIS
 1400           UQX(LTT)  = UQXT*DC1L(LTT)  + UQYT*DC2L(LTT)
                UQY(LTT)  = -  UQXT*DC2L(LTT)  + UQYT*DC1L(LTT)
         GO TO 1600
COMMENT - AXIS OPTION 1 - LOADS ALLREADY IN MEMBER AXES
 1500           UQX(LTT)  = UQXT
                UQY(LTT)  = UQYT
 1600           NCDL(LTT)  = 0
                IAXOPL(LTT)  = IAXOPT
                IOVRM(LTT)  = IOVERT
         GO TO 4900
COMMENT - VARIABLE LOADING
 2400    CONTINUE
         IF (UQXT .NE. 0 .OR.  UQYT .NE. 0) GO TO 8670
                NCDL(LTT)  = NCDLT
                IAXOPL(LTT)  = IAXOPT
      PRINT 18, LTT
COMMENT - DO FOR EACH ADDITIONAL CARD OF LOAD TYPE
         DO 4500  II = 1,NCDLT
                NC6 = NC6 + 1
         IF (II .EQ. 1) NC61(LTT) = NC6
         IF (NCR6.EQ. NCD6) GO TO 8560
COMMENT - READ AND PRINT NONUNIFORM LOAD DATA
      READ  15, XLL(NC6),XRL(NC6),QXLT,QYLT,QZL(NC6),IOVRL(NC6)
      PRINT 16, XLL(NC6),XRL(NC6),QXLT,QYLT,QZL(NC6),IOVRL(NC6)
                NCR6 = NCR6 + 1
                TH = ZLL(LTT)/M
COMMENT - CONVERT DISTANCES TO MEMBER COORDINATES
         GO TO   (2800,2800,2700,2600), IAXOPT
 2600           XLL(NC6)  = XLL(NC6)/DC2L(LTT)
                XRL(NC6)  = XRL(NC6)/DC2L(LTT)
         GO TO 2800
 2700           XLL(NC6)  = XLL(NC6)/DC1L(LTT)
                XRL(NC6)  = XRL(NC6)/DC1L(LTT)
 2800    CONTINUE
COMMENT - CHECK FOR ILLEGAL DATA
         IF (XLL(NC6)  .LT. 0.0) GO TO 8540
         IF (XRL(NC6)  .GT.  ZLL(LTT) + 0.1*TH) GO TO 8520
         IF (XRL(NC6)  .EQ. 0.0) GO TO 2838
         IF (II .EQ. 1) GO TO 2820
         IF (XRL(NC6 - 1) .NE. 0.0) GO TO 2820
         IF (XLL(NC6)  .NE. 0.0) GO TO 8550
                DEL = XRL(NC6) - XLL(NC6 - 1)
         GO TO 2830
 2820           DEL = XRL(NC6) - XLL(NC6)
 2830    IF (DEL .EQ. 0.0) GO TO 2840
         IF (DEL .LE. TH) GO TO 8530
         GO TO 2840
 2838           DEL = 1.0
         IF (II .EQ. 1) GO TO 2840
         IF (XLL(NC6) .EQ. 0.0 .AND. XRL(NC6 - 1) .EQ. 0.0) GO TO 8610
 2840    CONTINUE
         IF (IAXOPT .EQ. 1) GO TO 2900
         IF (IAXOPT .EQ. 2 .OR. DEL .EQ. 0.0) GO TO 2850
COMMENT - AXIS APTIONS 3 OR 4 - CONVERT DISTRIBUTED LOADS TO DIRECTIONS
COMMENT - AND INTENSITY OF MEMBER AXES
                TEMP1 = DC1L(LTT)
                TEMP2 = DC2L(LTT)
         IF ( TEMP1 .LT. 0.0) TEMP1 = - TEMP1
         IF ( TEMP2 .LT. 0.0) TEMP2 = - TEMP2
                QXL(NC6)  =   QXLT*DC1L(LTT)*TEMP2 +
     2                       QYLT*DC2L(LTT)*TEMP1
                QYL(NC6)  = -QXLT*DC2L(LTT)*TEMP2 +
     2                       QYLT*DC1L(LTT)*TEMP1
         GO TO 2950
 2850    CONTINUE
COMMENT - AXIS OPTION 2 OR CONCENTRATED LOADS - CONVERT DISTRIBUTED
COMMENT - AND CONCENTRATED LOADS TO DIRECTIONS OF MEMBER AXES
                QXL(NC6)  = QXLT*DC1L(LTT)  + QYLT*DC2L(LTT)
                QYL(NC6)  = -QXLT*DC2L(LTT)  + QYLT*DC1L(LTT)
         GO TO 2950
 2900    CONTINUE
COMMENT - AXIS OPTION 1 - LOADS ALLREADY IN MEMBER AXES
                QXL(NC6)  = QXLT
                QYL(NC6)  = QYLT
 2950    CONTINUE
 4500    CONTINUE
 4900    CONTINUE
         IF (NCR6 .LT. NCD6) GO TO 8580
         GO TO 9900
 8520 PRINT 52
         GO TO 9700
 8530 PRINT 53
         GO TO 9700
 8540 PRINT 54
         GO TO 9700
 8550 PRINT 55
         GO TO 9700
 8560 PRINT 56
         GO TO 9700
 8570 PRINT 57
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      GO TO 9700
8580 PRINT 58
      GO TO 9700
8590 PRINT 59
      GO TO 9700
8600 PRINT 60
      GO TO 9700
8610 PRINT 61
      GO TO 9700
8620 PRINT 62
      GO TO 9700
8650 PRINT 65
      GO TO 9700
8670 PRINT 67
      GO TO 9700
8710 PRINT 71
      GO TO 9700
8720 PRINT 72
9700        IABAN = 1
9900     CONTINUE
            NLTL = NLT
     RETURN
     END


********************************** SUBROUTINE **********************************
      SUBROUTINE ITCONT
COMMENT - SUBROUTINE ITCONT INPUTS ITERATION CONTROL DATA, CHECKS FOR
COMMENT - BAD DATA AND ECHO PRINTS DATA
      IMPLICIT REAL*8 (A-H,O-Z)
      COMMON /BLOCK1/ X(25),        Y(25),        CXX(25),      QYY(25),
     2     QZZ(25),      SXX(25),      SYY(25),      SZZ(25),      DXX(25),
     3     DYY(25),      DZZ(25),      RXX(25),      RYY(25),      RZZ(25),
     4     ERXX(25),     ERYY(25),     ERZZ(25),     QMJ(25),      WMJ(25),
     5     NSXX(25),     NSYY(25),     NSZZ(25),     IMJ(25),      NSXP(25),
     6     NSYP(25),     ISTJR(25)
      COMMON /BLOCK4/ FOMM(50,6),SMC(50,21),IST(50),   LT(50),
     2    JT1(50),      JT2(50),       NITM(50),    IMM(50),    IMC(50)
      COMMON /BLK1/  TOL,    ELEMNT,NJST,   KEEP3C,NCD3C,
     2         KEEP2, KEEP3A,KEEP3B,KEEP4A,KEEP4B,KEEP4C,KEEP5A,
     3         KEEP5B,KEEP5C,KEEP5D,KEEP6, KEEP7, NCD2,  NCD3A,
     4         NCD3B, NCD4A, NCD4B, NCD4C, NCD5A, NCD5B, NCD5C,
     5         NCD5D, NCD6,  NCD7,  IP8,   IP9,   IP10,  ITYPE,
     6         IABAN, IFORE, NM,    NJT,   NST,   NLT,   M,
     7         MP1,   MP2,   ISTT,  LTT,   ITYPEL,IDJ,   NSTL
      COMMON/ITC/ ERR1,ERR2,ER1,ER2,DTI,CM,NTI,MM(20),MJ(20),MNITF,
     2         MNITM,NSMJ,NSMM
      COMMON / BR / PCRML, PCRJL, NLR, NLRA
      COMMON /SKT21/ NTR, NTRA
      COMMON /GT/ MJO
    9 FORMAT (    40H     TABLE 7 -  ITERATION CONTROL          ,///)
   14 FORMAT (4I5,3E10.3,F5.2,5I5,/,16I5)
   15 FORMAT (E10.3,2I5,2E10.3,10X,F5.2,5I5,/,16I5)
   17 FORMAT (    43H     HOLDING DATA FROM THE PREVIOUS PROBLEM,///)
   18 FORMAT (15X,14HFRAME SOLUTION,//,27H LOAD TIME NUMB NUMB  FORCE,5X
     2,59HMOMENT   LENGTH OF  JNT.LOAD   NO.OF MON            MONITOR,/,
     3 27H NRED NRED ITER STEPS ERROR,6X,19HERROR    TIME STEP  ,
     4 38HRED.PRCNT   JOINTS                  JOINTS,//)
   19 FORMAT (///,15X,28HDAMPING AND MEMBER SOLUTIONS,//,3X,4HDAMP,5X,
     2 7HMONITOR,2X,4HNUMB,2X,16HFORCE      MOMENT,9X,8HMEM.LOAD,2X,
     3 9HNO.OF MON,13X,7HMONITOR,/,3X,5HCOEFF,3X,9HJOINT OPT,1X,4HITER,
     4 2X,5HERROR,6X,5HERROR,9X,9HRED.PRCNT,2X,7HMEMBERS,14X,7HMEMBERS,
     5 /)
   24 FORMAT (4I5,3E10.3,4X,F5.2,3X,I5,5X,5I5,/,(72X,5I5))
   25 FORMAT (E10.3,1X,I5,4X,I5,2E10.3,9X,F5.2,3X,I5,5X,5I5,/,(72X,5I5))
   71 FORMAT (    45H MAXIMUN NUMBER OF ITERATIONS PERMITTED IS 20)
   72 FORMAT (    43H MONITOR JOINT NUMBER TOO LARGE OR NEGATIVE )
   73 FORMAT (    45H MONITOR MEMBER NUMBER TOO LARGE OR NEGATIVE )
   74 FORMAT (51H SPECIFIED NUMBER OF MONITOR JOINTS IS GREATER THAN,
     2 30HEITHER 20 OR THE TOTAL NUMBER ,/,20H OF FRAME JOINTS OR ,
     3  8HNEGATIVE)
   75 FORMAT (52H SPECIFIED NUMBER OF MONITOR MEMBERS IS GREATER THAN,
     2 30HEITHER 21 OR THE TOTAL NUMBER ,/,21H OF FRAME MEMBERS OR ,
     3  8HNEGATIVE)
   76 FORMAT (52H MONITOR MEMBER NUMBERS HAVE TO BE IN THE ASCENDING ,
     2  5HORDER)
   77 FORMAT (47H NUMBER OF MONITOR JOINTS IS NOT EQUAL TO INPUT,
     2 15H MONITOR JOINTS)
   78 FORMAT (48H NUMBER OF MONITOR MEMBERS IS NOT EQUAL TO INPUT,
     2 16H MONITOR MEMBERS)
   87 FORMAT (    45H     IF TABLE 7 IS HELD NO CARDS MAY BE ADDED)
COMMENT - PRINT TABLE HEADING
      PRINT 9
         IF (KEEP7 .EQ. 1  .AND. NCD7 .NE. 0) GO TO 8700
         IF (KEEP7 .EQ. 1) GO TO 2010
      READ 14, NLRA,NTRA,MNITF,NTI,ERR1,ERR2,DTI,PCRJL,NSMJ,
     2        (MJ(I),I=1,20)
      READ 15, CM,MJO,MNITM,ER1,ER2,PCRML,NSMM,(MM(I),I=1,20)
         GO TO 2100
 2010 PRINT 17
 2100 PRINT 18
      PRINT 24, NLRA,NTRA,MNITF,NTI,ERR1,ERR2,DTI,PCRJL,NSMJ,
     2        (MJ(I),I=1,20)
         IF (NSMJ.GT.20 .OR. NSMJ.GT.NJT .OR. NSMJ.LT.0) GO TO 8740
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      IF (MNITF .GT. 20)  GO TO 8710
      DO 2200 I = 1,20
      IF (MJ(I) .GT. NJT .OR. MJ(I) .LT. 0)  GO TO 8720
 2200 CONTINUE
    PRINT 26,MJO
   26 FORMAT (/, 30H MONITOR JOINT OUTPUT OPTION =,I5,/)
    PRINT 19
    PRINT 25, CM,MJC,MNITM,ER1,ER2,PCRML,NSMM,(MM(I),I=1,20)
      IF (NSMM.GT.20 .OR. NSMM.GT.NM .OR. NSMM.LT.0) GO TO 8750
      IF (MNITM .GT. 20)  GO TO 8710
      DO 2300 I = 1,20
      IF (MM(I) .GT. NM .OR. MM(I) .LT. 0)  GO TO 8730
 2300 CONTINUE
      IF (KEEP7 .EQ. 1) GO TO 9900
      IF (NSMM .LT. 2) GO TO 3510
      DO 3500 I = 2,NSMM
         IM1 = I - 1
      IF (MM(I) .LT. MM(IM1)) GO TO 8760
 3500 CONTINUE
 3510 CONTINUE
COMMENT - SET JOINT SWITCH EQUAL TO 1 FOR MONITOR JOINTS
COMMENT - CHECK WHETHER SPECIFIED NUMBER OF MONITOR JOINTS ARE INPUT
         KOUNT = 0
      DO 3600  I = 1,NJT
         IMJ(I) = 0
      DO 3600  J = 1,20
      IF (I .NE. MJ(J)) GO TO 3600
         IMJ(I) = 1
         KOUNT = KOUNT + 1
 3600 CONTINUE
      IF (KOUNT .NE. NSMJ) GO TO 8770
COMMENT - SET MEMBER SWITCH EQUAL TO 1 FOR MONITOR MEMBERS
COMMENT - CHECK WHETHER SPECIFIED NUMBER OF MONITOR MEMBERS ARE INPUT
         KOUNT = 0
      DO 3800  I = 1,NM
         IMM(I) = 0
      DO 3800  J = 1,20
      IF (I .EQ. MM(J))  IMM(I) = 1
      IF (I .NE. MM(J)) GO TO 3800
         IMM(I) = 1
         KOUNT = KOUNT + 1
 3800 CONTINUE
      IF (KOUNT .NE. NSMM) GO TO 8780
      GO TO 9900
 8700 PRINT 87
      GO TO 9700
 8710 PRINT 71
      GO TO 9700
 8720 PRINT 72
      GO TO 9700
 8730 PRINT 73
      GO TO 9700
 8740 PRINT 74
      GO TO 9700
 8750 PRINT 75
      GO TO 9700
 8760 PRINT 76
      GO TO 9700
 8770 PRINT 77
      GO TO 9700
 8780 PRINT 78
 9700       IABAN = 1
 9900    CONTINUE
      RETURN
      END


************************************ SUBROUTINE ************************************
      SUBROUTINE FORMST ( RM, RC, W, SL, SMMT, L1, L3, L4, L6, JJ )
COMMENT - SUBROUTINE FORMST CALCULATES MEMBER (6 X 6) STIFFNESS MATRIX
COMMENT - AND TAKING ADVANTAGE OF SYMETRY STORES IN COMPACT VECTOR
COMMENT - SMMT(I = 1, 21)
COMMENT - MEMBER 6 X 6 STIFFNESS MATRIX STORED AS 21 X 1 VECTOR SMMT AS
COMMENT - SHOWN BELOW
COMMENT -     1     S           R          L
COMMENT -     2     7     Y          I
COMMENT -     3     8     12    M          C
COMMENT -     4     9     13    16    M          A
COMMENT -     5     10    14    17    19    E
COMMENT -     6     11    15    18    20    21     T
      IMPLICIT REAL*8 (A-H,O-Z)
      DIMENSION FMMI(6), SMMT(21)
      DIMENSION RM(L6,L4), RO(L6), W(L6)
      COMMON /BLOCK2/ DXS( 25),   DYS( 25),   ZLS( 25),   DC1S( 25),
     2     DC2S( 25),   PRF( 25),   PRAL( 25),  QM( 25),    WM( 25),
     3     PRAG(25),    ELEMN(25),
     4     IOPOP( 25),  IPINL( 25), IPINR( 25), NC51( 25),  INLOP( 25),
     5     NAL( 25),    NSXL( 25),  NSYL( 25),  NSZL( 25),  NAR( 25),
     6     NSXR( 25),   NSYR( 25),  NSZR( 25),  NCDS( 25),  IAXCPS( 25)
      COMMON /BLOCK5/ XLS( 50),   XRS( 50),   FL( 50),    AEL( 50),
     2     SXL( 50),    SYL( 50),   SZL( 50)
      COMMON /BLOCK7/ F( 22),     AE( 22),    SX( 22),    SY( 22),
     2     SZ( 22),     IX( 22),    QY( 22),    QZ( 22),    DX( 22),
     3     DY( 22),     DZ( 22),    ERX( 22),   ERY( 22),   ERZ( 22),
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4       SQX( 22),     SQY( 22),     SQZ( 22),     U1( 22),     V1( 22),
5       W1( 22),      U2( 22),      V2( 22),      W2( 22),     DS(3,3, 22),
6       BM1S( 22),    BM2S( 22),    TTS( 22),     AG( 22)
 COMMON /BLOC12/ SM(20,10),    EM(20,10),    BI(20,10),   DI(20,10),
2       YI(20,10),    NSS(20,10),   NA(20),       NCDA(20),    IRECT(20,10)
 COMMON /BLOC13/ NPTS( 08),     ISS( 08),    NSIG(08,11),NEPS(08,11),
2       NSIT(11),     NEPT(11)
 COMMON /BLOC14/ NPTM( 20),     ISM( 20),    NQM(20,11), NWM(20,11),
2       NQMT(11),     NWMT(11)
 COMMON /BLK1/  TOL,      ELEMNT,NJST,  KEEP3C,NCD3C,
2             KEEP2, KEEP3A,KEEP3B,KEEP4A,KEEP4B,KEEP4C,KEEP5A,
3             KEEP5B,KEEP5C,KEEP5D,KEEP6, KEEP7, NCD2,  NCD3A,
4             NCD3B, NCD4A, NCD4B, NCD4C, NCD5A, NCD5B, NCD5C,
5             NCD5D, NCD6,  NCD7,  IP8,   IP9,   IP10,  ITYPE,
6             IABAN, IFCRM, NM,    NJT,   NST,   NLT,   M,
7             MP1,   MP2,   ISTT,  LTT,   ITYPEL,IDJ,   NSTL
 COMMON /BLK2/ XL,XR,X1,X2,             H,TH,HSQ,HCU,X2L,I1,I2,NQ
 COMMON /BLK3/ MNJT,MNST,MNLT,MNM,MNC5,MNC6,MDJT,MNJS,MNE,MNCS,
2     MNPCS,MNSS,MNQWM,MNJST,MNJSS
 COMMON /BLK4/ ST1,ST2,ST3,ST4,ST5,ST6
 COMMON /BLK5/ NPSUB,NITF,N1,N2
 COMMON /BLK6/ QT1,QT2,QT3,QT4,QT5,QT6
 COMMON /BLK7/ INLOPT,IFAE,KOFFJ,KOFFQW,KOFFSE
 COMMON / RI / NL, ML, J1
 COMMON /SKT5/         WRXM (21,10),  WRYM (21,10),  WRZM (21,10),
2                      WRTXM(21,10),  WRTYM(21,10),  WRTZM(21,10)
 COMMON /SKT10/        NDIV(20,10),   NPCTOT(20)
 COMMON /SKT11/        MSSINL,        MSSIM1
 COMMON /SKT13/        EPR1S(21,10,3),EPRT1S(21,10,3),
2                      EPR2S(21,10,3),EPRT2S(21,10,3)
 COMMON /SKT14 / IRV(21,2,10),                   FOMOLD(50,6),
2                IRVRSE,         ITAPE,          N3
 COMMON /SKT20/ MCRGCN(21,3), MCUREV(21,3)
 COMMON /SKT30/ MSTIP(25), MLOAD(25), MODEL(25)
 COMMON /SKT32/ EPBF1 (21,10,3), EPBFT1(21,10,3), SLBF1 (21,10,3),
2               SLBFT1(21,10,3), EPBF2 (21,10,3), EPBFT2(21,10,3),
3               SLBF2 (21,10,3), SLBFT2(21,10,3),
4               EPSMAX(21,2,10), EPSMIN(21,2,10), EPSPRE(21,2,10),
5               YGROW (21,2,10), YIGROW(21,2,10)
 COMMON /SKT35/ TMESTP
       DATA ANEW /4HANEW/, ANONE /5HANONE/
       DATA SHEAR /5HSHEAR/
    IF ( ITYPE .LE. 2 ) TMESTP = ANONE
COMMENT - SET TEMPORARY CONTROL CONSTANTS FOR STIFF TYPE ISTT
       M = MSTIF (ISTT)
       MP1= M+1
       MP2= M+2
       IPINLT = IPINL(ISTT)
       IPINRT = IPINR(ISTT)
       ZL = ZLS(ISTT)
       NCDST = NCDS(ISTT)
       NC51T = NC51(ISTT)
       INLOPT = INLOP(ISTT)
       MODELT = MODEL(ISTT)
       ELEMNT = ELEMN(ISTT)
    IF ( INLOPT .EQ. 0 ) GO TO 1000
       NALT   = NAL(ISTT)
       NCDAT  = NCDA(ISTT)
       NREAD = NSXL(ISTT)+NSYL(ISTT)+NSZL(ISTT)
1000  CONTINUE
COMMENT - COMPUTE CONSTANTS FOR MEMBER SOLUTIONS FOR STIFFNESS VALUES
       TH = ZL/M
       H = 0.5*TH
       HSQ = H*H
       HCU = HSQ*H
       NL = 3*MP1
       ML = 1
       NFSUB = 22
    IF ( ELEMNT .EQ. SHEAR ) GO TO 5000
    IF ( TMESTP .EQ. ANEW ) GO TO 1200
    IF ( ITYPE .GE. 3 ) GO TO 1300
    IF (NITF .GT. 1) GO TO 1200
    IF (ITYPE .EQ. 2) GO TO 1200
COMMENT - ZERO MEMBER DISPLACEMENTS
    DO 1150  I = 1,MP2
       DX(I) = 0.0
       DY(I) = 0.0
1150   DZ(I) = 0.0
    IF ( INLOPT .EQ. 0 ) GO TO 1300
    IF ( NREAD  .EQ. 0 ) GO TO 1158
COMMENT - INITIALISE UR AND URT VALUES FOR EACH ELEMENT, AND
COMMENT - FOR THE THREE CURVES  X, Y, AND Z AND FOR EACH SUB-COMPONENT
    DO 1155 I = 2,MP1
    DO 1155 J = 1,10
       WRXM (I,J) = 0.0
       WRTXM(I,J) = 0.0
       WRYM (I,J) = 0.0
       WRTYM(I,J) = 0.0
       WRZM (I,J) = 0.0
       WRTZM(I,J) = 0.0
1155  CONTINUE
COMMENT - INITIALISE REVERSAL CHECK INDICATORS FOR ALL THE THREE
COMMENT - MEMBER-SUPPORT SPRINGS AT CENTRE OF EACH ELEMENT
    DO 1157 I = 2,MP1
    DO 1157 N = 1,3
       MCUREV(I,N) = 0
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 1157      CONTINUE
 1158      CONTINUE
         . IF ( MODELT .LE. -1 ) GC TO 1300
COMMENT - INITIALISE EPSILONR & EPSILONET FOR EACH ELEMENT  I ,
COMMENT - AT BOTH HINGES ( 1 & 2 ), FOR A MAXIMUM OF  MNPCS  PIECES
COMMENT - AND  MSSIM1  COMPONENT  SIGMA-EPSILON CURVES
           DO 1160 I = 2,MP1
           DO 1160 J = 1,MNPCS
           DO 1160 K = 1,MSSIM1
                EPR1S  (I,J,K) = 0.0
                EPRT1S (I,J,K) = 0.0
                EPR2S  (I,J,K) = 0.0
                EPRT2S (I,J,K) = 0.0
 1160      CONTINUE
           IF ( MODELT .EC. 0 ) GC TO 1185
COMMENT - INITIALISE BIFURCATION STRAIN & SLOPE AND THEIR TEMPORARY
COMMENT - VALUES ALSO FOR HINGES 1 & 2 .
           DO 1165 I = 2,MP1
           DO 1165 J = 1,MNPCS
           DO 1165 K = 1,MSSIM1
                EPBF1  (I,J,K) = 0.0
                EPBFT1 (I,J,K) = 0.0
                SLBF1  (I,J,K) = 0.0
                SLBFT1 (I,J,K) = 0.0
                EPBF2  (I,J,K) = 0.0
                EPBFT2 (I,J,K) = 0.0
                SLBF2  (I,J,K) = 0.0
                SLBFT2 (I,J,K) = 0.0
 1165      CONTINUE
COMMENT - ASSIGN PROPER INITIAL VALUES TO MAX.STRAIN, MIN.STRAIN,
COMMENT - PREVIOUS STRAIN, YIELDGROWTH LEVEL, & ITS TEMPORARY VALUE
COMMENT - FOR EACH SUBRECTANGLE OF THE CROSS SECTION AT BOTH HINGES
COMMENT - OF EACH ELEMENT.
           DO 1180 I = 2,MP1
           DO 1180 L = 1,2
                ICUMU   = 0
           DO 1175 J = 1,NCDAT
                NSSLT  = NSS(NALT,J)
                NDIVT  = NDIV(NALT,J)
                SIGMA  = NSIG(NSSLT,2) * SM(NALT,J)
                PSLCN  = NEPS(NSSLT,2) * EM(NALT,J)
           DO 1170 IDVT = 1,NDIVT
                ICUMU  = ICUMU  + 1
                EPSMAX(I,L,ICUMU) =  PSLON
                EPSMIN(I,L,ICUMU) = -PSLCN
                EPSPRE(I,L,ICUMU) =  0.0
           IF ( MODELT .NE. 2 ) GC TO 1170
                YGROW (I,L,ICUMU) = SIGMA
                YTGRCW(I,L,ICUMU) = SIGMA
 1170      CONTINUE
 1175      CONTINUE
           IF ( ICUMU .GE. MNPCS ) GO TO 1180
                IBEGIN = ICUMU + 1
           DO 1177 ICUMU = IBEGIN , MNPCS
                EPSMAX(I,L,ICUMU) =  PSLON
                EPSMIN(I,L,ICUMU) = -PSLON
                EPSPRE(I,L,ICUMU) =  0.0
           IF ( MODELT .NE. 2 ) GO TO 1177
                YGROW (I,L,ICUMU) = SIGMA
                YTGRCW(I,L,ICUMU) = SIGMA
 1177      CONTINUE
 1180      CONTINUE
 1185      CONTINUE
COMMENT - INITIALISE REVERSAL CHECK INDICATOR FOR EACH ELEMENT, AT BOTH
COMMENT - HINGES 1&2 , FCR A MAXIMUM OF MNPCS SUBRECTANGLES
           DO 1195 I = 2 , MP1
           DO 1195 L = 1 , 2
           DO 1195 J = 1 , MNPCS
                IRV ( I,L,J ) = 0
 1195      CONTINUE
           GO TO 1300
COMMENT - READ MEMBER DISPLACEMENTS
 1200 READ (N1)  (DX(I) , DY(I) , DZ(I) , I = 1,MP2)
           IF ( INLCPT .EQ. 0 ) GO TO 1300
           IF ( NREAD  .EQ. 0 ) GO TO 1250
COMMENT - READ RESIDUAL & TEMPORARY RESIDUAL DISPLACEMENTS OF
COMMENT - MEMBER SUPPORT CURVES ( THEIR COMPCNENTS )
       READ  (N1) ( ( WRXM(I,J), WRTXM(I,J), WRYM(I,J), WRTYM(I,J),
     2WRZM(I,J), WRTZM(I,J), J=1,10), I=2,MP1 )
COMMENT - READ REVERSAL INDICATORS FOR MEMBER-SUPPORT SPRINGS
       READ  (N3) ((MCUREV(I,N), N=1,3), I=2,MP1 )
 1250      CONTINUE
           IF ( MODELT .LE. -1 ) GO TO 1300
COMMENT - READ RESIDUAL & TEMPORARY RESIDUAL STRAINS
       READ (N1) ((( EPR1S(I,J,K) , EPRT1S(I,J,K), EPR2S(I,J,K),
     2              EPRT2S(I,J,K) , K = 1,MSSIM1), J=1,MNPCS), I=2,MP1 )
           IF ( MODELT .EQ. 0 ) GC TO 1260
       READ  (N1    ) (((EPBF1 (I,J,K), EPBFT1(I,J,K), SLBF1 (I,J,K),
     2                   SLBFT1(I,J,K), EPBF2 (I,J,K), EPBFT2(I,J,K),
     3                   SLBF2 (I,J,K), SLBFT2(I,J,K), K=1,MSSIM1 ),
     4                   J = 1,MNPCS ), I = 2,MP1 )
       READ  (N1    ) (((EPSMAX(I,L,J), EPSMIN(I,L,J), PPSPRE(I,L,J),
     2                   J = 1,MNPCS ), L = 1,2 ), I = 2,MP1 )
           IF ( MODELT .NE. 2 ) GO TO 1260
       READ  (N1    ) (((YGROW (I,L,J), YTGROW(I,L,J), J = 1,MNPCS ),
     2                   L = 1,2 ), I = 2,MP1 )
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 1260     CONTINUE
COMMENT - READ REVERSAL INDICATORS FOR STRAINS
      READ (N3)   (((IRV(I,L,J),J=1,MNPCS),L=1,2),I=2,MP1)
 1300     CONTINUE
COMMENT - ZERO MEMBER INCREMENTAL LOADS
          DO 1800  I = 1,MP2
                ERX(I) = 0.0
                ERY(I) = 0.0
 1800           ERZ(I) = 0.0
          IF (INLOPT .EQ. 1) GO TO 2400
          IF (NCDST .EQ. 0) GO TO 2100
COMMENT - SUBROUTINE DISCST DISCRETIZES MEMBER LINEAR STIFFNESS DATA
COMMENT - F, AE, SX, SY, SZ
      CALL        DISCST ( NC51T, NCDST, ZL, L1 )
          GO TO 2500
 2100     CONTINUE
COMMENT - PRISMATIC MEMBER WITH CONSTANT F AND AE
                PRFT = PRF(ISTT)
                PRAET = PRAE(ISTT)
          DO 2200  I = 1,MP2
                SX(I) = 0.0
                SY(I) = 0.0
                SZ(I) = 0.0
                SQX(I) = 0.0
                SQY(I) = 0.0
                SQZ(I) = 0.0
                AE(I) = PRAET
                F(I) = PRFT
 2200     CONTINUE
                AE(1) = 0.0
                AE(MP2) = 0.0
                F(1) = 0.0
                F(MP2) = 0.0
          GO TO 2500
 2400     CONTINUE
          IF ( TMESTP .EQ. ANEW ) GO TO 2405
          IF ( ITYPE .GE. 3 ) GO TO 2600
 2405     CONTINUE
          IF ( NREAD .NE. 0 ) GO TO 2420
          DO 2410 I = 1,MP2
                SX  (I) = 0.0
                SY  (I) = 0.0
                SZ  (I) = 0.0
                SQX (I) = 0.0
                SQY (I) = 0.0
                SQZ (I) = 0.0
 2410     CONTINUE
          GO TO 2500
 2420     CONTINUE
COMMENT - SUBROUTINE NLSS DISCRETIZES DISTRIBUTED MEMBER Q - W CURVES
COMMENT - TO STATION VALUES OF RESISTIVE SPRING FORCES  SQX, SQY, SQZ
COMMENT - AND SPRING STIFFNESS  SX, SY, SZ
      CALL        NLSS  ( L1, JJ )
          GO TO 2500
 5000     CONTINUE
          IF (TMESTP .EQ. ANEW) GO TO 5200
          IF (ITYPE .GE. 3) GO TO 5300
          IF (NITF .GT. 1) GO TO 5200
          IF (ITYPE .EQ. 2) GO TO 5200
COMMENT - ZERO MEMBER DISPLACEMENTS
          DO 5150 I = 1,MP2
                DX(I) = 0.0
                DY(I) = 0.0
 5150           DZ(I) = 0.0
          IF ( INLOPT .EQ. 0 )  GO TO 5300
          IF ( NREAD  .EQ. 0 )  GO TO 5158
COMMENT - INITIALISE  UR  AND  URT  VALUES FOR EACH ELEMENT, AND
COMMENT - FOR THE THREE CURVES  X, Y, AND Z AND FOR EACH SUB-COMPONENT
          DO 5155 I = 2,MP1
          DO 5155 J = 1,10
                WRXM (I,J) = 0.0
                WRTXM(I,J) = 0.0
                WRYM (I,J) = 0.0
                WRTYM(I,J) = 0.0
                WRZM (I,J) = 0.0
                WRTZM(I,J) = 0.0
 5155     CONTINUE
COMMENT - INITIALISE REVERSAL CHECK INDICATORS FOR ALL THE THREE
COMMENT - MEMBER-SUPPORT SPRINGS AT CENTRE OF EACH ELEMENT
          DO 5157 I = 2,MP1
          DO 5157 N = 1,3
                MCUREV(I,N) = 0
 5157     CONTINUE
 5158     CONTINUE
          IF ( MODELT .LE. -1 ) GO TO 5300
COMMENT - INITIALISE EPSILONR & EPSILCNRT FOR EACH SHEAR ELEMENT  I
COMMENT - AT THE HINGE, FOR A MAXIMUM OF MNPCS PIECES AND MSSIM1
COMMENT - COMPONENT SIGMA-EPSILON CURVES
          DO 5160 I = 2,MP1
          DO 5160 J = 1,MNPCS
          DO 5160 K = 1,MSSIM1
                EPR1S (I,J,K) = 0.0
                EPRT1S(I,J,K) = 0.0
 5160     CONTINUE
          IF ( MODELT .EQ. 0 ) GO TO 5185
COMMENT - INITIALISE BIFURCATION STRAIN & SLOPE AND THEIR TEMPORARY
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COMMENT - VALUES AT THE HINGE
          DO 5165 I = 2,MP1
          DO 5165 J = 1,MNPCS
          DO 5165 K = 1,MSSIM1
                EPBF1 (I,J,K) = 0.0
                EPBFT1(I,J,K) = 0.0
                SLBF1 (I,J,K) = 0.0
                SLBFT1(I,J,K) = 0.0
 5165     CONTINUE
COMMENT - ASSIGN PROPER INITIAL VALUES TO MAX.STRAIN, MIN.STRAIN,
COMMENT - PREVIOUS STRAIN, YIELDGROWTH LEVEL, & ITS TEMPORARY VALUE
COMMENT - FOR EACH SUBRECTANGLE OF THE CROSS SECTION AT THE HINGE
COMMENT - OF EACH ELEMENT.
          DO 5180 I = 2,MP1
               ICUMU   = 0
          DO 5175 J = 1,NCDAT
               NSSLT  = NSS (NALT,J)
               NDIVT  = NDIV(NALT,J)
               SIGMA  = NSIG(NSSLT,2) * SM(NALT,J)
               PSLON  = NEPS(NSSLT,2) * EM(NALT,J)
          DO 5170 IDVT = 1,NDIVT
               ICUMU  = ICUMU  + 1
               EPSMAX(I,1,ICUMU) =  PSLON
               EPSMIN(I,1,ICUMU) = -PSLON
               EPSPRE(I,1,ICUMU) =  0.0
          IF ( MODELT .NE. 2 ) GO TO 5170
               YGROW (I,1,ICUMU) = SIGMA
               YTGROW(I,1,ICUMU) = SIGMA
 5170     CONTINUE
 5175     CONTINUE
          IF ( ICUMU .GE. MNPCS ) GO TO 5180
               IBEGIN = ICUMU + 1
          DO 5177 ICUMU = IBEGIN , MNPCS
               EPSMAX(I,1,ICUMU) =  PSLON
               EPSMIN(I,1,ICUMU) = -PSLON
               EPSPRE(I,1,ICUMU) =  0.0
          IF ( MODELT .NE. 2 ) GO TO 5177
               YGROW (I,1,ICUMU) = SIGMA
               YTGROW(I,1,ICUMU) = SIGMA
 5177     CONTINUE
 5180     CONTINUE
 5185     CONTINUE
COMMENT - INITIALISE REVERSAL CHECK INDICATOR FOR EACH ELEMENT, AT THE
COMMENT - HINGE , FOR A MAXIMUM OF MNPCS SUBRECTANGLES
          DO 5195 I = 2 , MP1
          DO 5195 J = 1 , MNPCS
               IRV  ( I,1,J ) = 0
 5195     CONTINUE
          GO TO 5300
COMMENT - READ MEMBER DISPLACEMENTS
 5200 READ (N1)   (DX(I) ,DY(I) ,DZ(I) , I=1,MP2)
          IF ( INLOPT .EQ. 0 ) GO TO 5300
          IF ( NREAD  .EQ. 0 ) GO TO 5250
COMMENT - READ RESIDUAL & TEMPORARY RESIDUAL DISPLACEMENTS OF
COMMENT - MEMBER SUPPORT CURVES ( THEIR COMPONENTS )
      READ  (N1) ( ( WRXM(I,J), WRTXM(I,J), WRYM(I,J), WRTYM(I,J),
     2WRZM(I,J), WRTZM(I,J) , J=1,10), I=2,MP1 )
COMMENT - READ REVERSAL INDICATORS FOR MEMBER-SUPPORT SPRINGS
      READ  (N3)  ((MCUREV(I,N), N=1,3), I=2,MP1 )
 5250     CONTINUE
          IF ( MODELT .LE. -1 ) GC TO 5300
COMMENT - READ RESIDUAL & TEMPORARY RESIDUAL STRAINS
      READ (N1) ((( EPR1S(I,J,K) , EPRT1S(I,J,K),
     2                K = 1,MSSIM1), J=1,MNPCS), I=2,MP1 )
          IF ( MODELT .EQ.  0 ) GO TO 5260
      READ  (N1    ) (((EPBF1 (I,J,K), EPBFT1(I,J,K), SLBF1 (I,J,K),
     2                   SLBFT1(I,J,K),K=1,MSSIM1 ),J=1,MNPCS ),I=2,MP1 )
      READ  (N1    )  ((EPSMAX(I,1,J), EPSMIN(I,1,J), EPSPRE(I,1,J),
     2                   J = 1,MNPCS ), I = 2,MP1 )
          IF ( MODELT .NE. 2 ) GO TO 5260
      READ  (N1    )  ((YGROW (I,1,J), YTGROW(I,1,J), J = 1,MNPCS ),
     2                   I = 2,MP1 )
 5260     CONTINUE
COMMENT - READ REVERSAL INDICATORS FOR STRAINS
      READ (N3)     ((IRV(I,1,J),J=1,MNPCS),I=2,MP1)
 5300     CONTINUE
COMMENT - ZERO MEMBER INCREMENTAL LOADS
          DO 5800 I = 1,MP2
                ERX(I) = 0.0
                ERY(I) = 0.0
 5800           ERZ(I) = 0.0
          IF (INLOPT .EQ. 1) GO TO 6400
COMMENT - PRISMATIC MEMBER WITH CONSTANT F,AE AND AG
                PRFT = PRF(ISTT)
                PRAET = PRAE(ISTT)
                PRAGT = PRAG(ISTT)
          DO 6200  I = 1,MP2
                SX(I) = 0.0
                SY(I) = 0.0
                SZ(I) = 0.0
                SQX(I) = 0.0
                SQY(I) = 0.0
                SQZ(I) = 0.0
                AE(I) = PRAET
                F(I) = PRFT
                AG(I) = PRAGT
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 6200      CONTINUE
                AE(1) = 0.0
                AE(MP2) = 0.0
                F(1) = 0.0
                F(MP2) = 0.0
                AG(1) = 0.0
                AG(MP2) = 0.0
           GO TO 2500
 6400      CONTINUE
           IF (TMESTP .EQ. ANEW) GC TO 6405
           IF (ITYPE .GE. 3) GO TO 2600
 6405      CONTINUE
           IF (NREAD .NE. 0) GO TO 6420
           DO 6410 I = 1,MP2
                SX(I) = 0.0
                SY(I) = 0.0
                SZ(I) = 0.0
                SQX(I) = 0.0
                SQY(I) = 0.0
                SQZ(I) = 0.0
 6410      CONTINUE
           GO TO 2500
 6420      CONTINUE
COMMENT - SUBROUTINE NLSS DISCRETIZES DISTRIBUTED MEMBER Q - W CURVES
COMMENT - TO STATION VALUES OF RESISTIVE SPRING FORCES  SQX, SQY, SQZ
COMMENT - AND SPRING STIFFNESS  SX, SY, SZ
      CALL       NLSS  ( L1, JJ )
 2500      CONTINUE
COMMENT - STORE MEMBER END RESTRAINTS ST1 -  ST6
                ST1 = SX(1)
                ST2 = SY(1)
                ST3 = SZ(1)
                ST4 = SX(MP1)
                ST5 = SY(MP1)
                ST6 = SZ(MP1)
 2600      CONTINUE
COMMENT - ZERO MEMBER-END-LOADS
                QT1 = 0.0
                QT2 = 0.0
                QT3 = 0.0
                QT4 = 0.0
                QT5=0.0
                QT6=0.0
COMMENT SET MEMBER END RESTRAINTS TO 1.0E20 FOR 6 MEMBER SOLUTIONS
                SX(1)=1.0E20
                SY(1) = 1.0E20
                SZ(1) = 1.0E20
                SX(MP1) = 1.0E20
                SY(MP1) = 1.0E20
                SZ(MP1) = 1.0E20
COMMENT - ZERO PINNED END ROTATION RESTRAINTS
           IF ( IPINLT .EQ. 1) SZ(1) = 0.0
           IF ( IPINRT .EQ. 1) SZ(MP1) = 0.0
COMMENT - UNIT INCREMENT OF DISP FOR FIRST COLUMN OF STIFF MATRIX
                ERX(1) = 1.0E20
COMMENT - CALL GRIP2A TO SOLVE MEMBER FOR UNIT INCREMENT OF DISPLACEMENT
                M5 = 5
           CALL GRIP2A (RM,RO,W,SL,L3,L4,L6,M5)
           IF (M5 .EQ. 5 ) GO TO 3300
           DO 3290 I = 1,21
 3290           SMMT(I) = -1.0D+10
                ML = -1
      GO TO 9900
 3300           ERX(1) = 0.0D+00
COMMENT - FORMST HAS ALREADY BEEN CALLED TO FORM STIFFNESS MATRICES.
COMMENT - WHEN PROCEEDING TO A NEW TIME STEP, FORMST IS AGAIN CALLED
COMMENT - BUT ONLY TO FORM INCREMENTAL FIXED END FORCES THROUGH
COMMENT - FURTHER CALL TO  FORMLD  . HENCE SKIP THE REST OF THE
COMMENT - COMPUTATICNS DEALING WITH STIFFNESS FORMATION
           IF ( TMESTP .EQ. ANEW )  ML = -1
           IF ( TMESTP .EQ. ANEW ) GC TC 9900
COMMENT - CALL MEMENI TO FIND INCREMENTAL END-FORCES WHICH ARE STIFFNESS
COMMENT - TERMS IN CNE COLUMN OF STIFFNESS MATRIX
      CALL         MEMENI ( W,FMMI,L6 )
           DO 3350  KK = 1,6
 3350           SMMT(KK) = FMMI(KK)
COMMENT - SET MULTIPLE LCAD OPTICN FOR REMAINING SOLUTIONS
                ML = -1
COMMENT - UNIT INCREMENT OF DISP FOR SECOND COLUMN OF STIFF MATRIX
                ERY(1) = 1.0E20
      CALL         GRIP2A ( RM,RO,W,SL,L3,L4,L6,5)
                ERY(1) = 0.0
      CALL         MEMENI ( W,FMMI,L6 )
           DO 3450  KK = 2,6
 3450           SMMT(KK + 5) = FMMI(KK)
           IF (IPINLT .LE. 0) GO TC 3500
COMMENT - ZERO STIFFNESS FOR PINNED CONNECTIONS
                SMMT( 3) = 0.0
                SMMT( 8) = 0.0
                SMMT(12) = 0.0
                SMMT(13) = 0.0
                SMMT(14) = 0.0
                SMMT(15) = 0.0
           GO TO 3575
COMMENT - UNIT INCREMENT OF DISP FOR THIRD  COLUMN OF STIFF MATRIX
 3500           ERZ(1) = 1.0E20
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      CALL      GRIP2A ( RM,RO,W,SL,L3,L4,L6,5)
                ERZ(1) = 0.0
      CALL      MEMENI ( W,FMMI,L6 )
          DO 3550  KK = 3,6
 3550           SMMT(KK +  9) = FMMI(KK)
COMMENT - UNIT INCREMENT OF DISP FOR FOURTH COLUMN OF STIFF MATRIX
 3575           ERX(MP1) = 1.0E20
      CALL      GRIP2A ( RM,RO,W,SL,L3,L4,L6,5)
                ERX(MP1) = 0.0
      CALL      MEMENI ( W,FMMI,L6 )
          DO 3650  KK = 4,6
 3650           SMMT(KK + 12) =  FMMI(KK)
COMMENT - UNIT INCREMENT OF DISP FOR FIFTH  COLUMN OF STIFF MATRIX
                ERY(MP1) = 1.0E20
      CALL      GRIP2A ( RM,RO,W,SL,L3,L4,L6,5)
                ERY(MP1) = 0.0
      CALL      MEMENI ( W,FMMI,L6 )
          DO 3750  KK = 5,6
 3750           SMMT(KK + 14) =  FMMI(KK)
          IF (IPINRT .LE. 0) GO TO 3800
COMMENT - ZERO STIFFNESS FOR PINNED CONNECTIONS
                SMMT( 6) = 0.0
                SMMT(11) = 0.0
                SMMT(15) = 0.0
                SMMT(18) = 0.0
                SMMT(20) = 0.0
                SMMT(21) = 0.0
          GO TO 9900
COMMENT - UNIT INCREMENT OF DISP FOR SIXTH  COLUMN OF STIFF MATRIX
 3800           ERZ(MP1) = 1.0E20
      CALL      GRIP2A ( RM,RO,W,SL,L3,L4,L6,5)
                ERZ(MP1) = 0.0
      CALL      MEMENI ( W,FMMI,L6 )
                SMMT(21) = FMMI(6)
 9900     CONTINUE
      RETURN
      END
```

```
******************************** SUBROUTINE **********************************
      SUBROUTINE DISCST ( NC51T, NCDST, ZL, L1)
COMMENT - SUBROUTINE DISCST DISCRETIZES MEMBER LINEAR STIFFNESS DATA
COMMENT - F, AE, SX, SY, SZ
COMMENT - NONLINEAR SPRING RESISTIVE FORCES SQX, SQY, SQZ ARE ZEROED
      IMPLICIT REAL*8 (A-H,O-Z)
      COMMON /BLOCK5/ XLS( 50),    XRS( 50),    FL( 50),    AEL( 50),
     2    SXL( 50),    SYL( 50),    SZL( 50)
      COMMON /BLOCK7/ F( 22),     AE( 22),     SX( 22),     SY( 22),
     2    SZ( 22),     QX( 22),     QY( 22),     QZ( 22),     DX( 22),
     3    DY( 22),     DZ( 22),     ERX( 22),    ERY( 22),    ERZ( 22),
     4    SQX( 22),    SQY( 22),    SQZ( 22),    U1( 22),     V1( 22),
     5    W1( 22),     U2( 22),     V2( 22),     W2( 22),     DS(3,3, 22),
     6    BM1S( 22),   BM2S( 22),   TTS( 22),    AG( 22)
      COMMON /BLK1/  TOL,    ELEMNT,NJST,   KEEP3C,NCD3C,
     2    KEEP2, KEEP3A,KEEP3B,KEEP4A,KEEP4B,KEEP4C,KEEP5A,
     3    KEEP5B,KEEP5C,KEEP5D,KEEP6, KEEP7,  NCD2,   NCD3A,
     4    NCD3B, NCD4A,  NCD4B, NCD4C,  NCD5A,  NCD5B,  NCD5C,
     5    NCD5D, NCD6,   NCD7,  IP8,    IP9,    IP10,   ITYPE,
     6    IABAN, IFORM,  NM,    NJT,    NST,    NLT,    M,
     7    MP1,   MP2,    ISIT,  LTI,    ITYPEL,IDJ,     NSTL
      COMMON /BLK2/ XL,XR,X1,X2,        H,TH,HSQ,HCU,X2L,I1,I2,NQ
COMMENT - ZERO MEMBER STIFFNESS DATA
      DO 1020 I = 1,MP2
                SX(I) = 0.0
                SY(I) = 0.0
                SZ(I) = 0.0
                F(I) = 0.0
                AE(I) = 0.0
                SQX(I) = 0.0
                SQY(I) = 0.0
                SQZ(I) = 0.0
 1020     CONTINUE
                ICOUNT = 0
                NC52T = NC51T - 1 + NCDST
COMMENT - II GOES FROM NC51T TO NC52T
                II = NC51T - 1
 1050           II = II + 1
COMMENT - READ DATA FROM ONE CARD IMAGE  (STIFFNESS AT LEFT OF SECTION)
                XL = XLS(II)
                XR = XRS(II)
                FLT = FL(II)
                AELT = AEL(II)
                SXLT = SXL(II)
                SYLT = SYL(II)
                SZLT = SZL(II)
          IF (XR .NE. 0.0) GO TO 1100
COMMENT - VARIABLE STIFFNESS SECTION READ ONE CARD IMAGE (STIFFNESS AT
COMMENT - RIGHT OF SECTION)
                II = II + 1
                XR = XRS(II)
                FRT = FL(II)
                AERT = AEL(II)
                SXRT = SXL(II)
                SYRT = SYL(II)
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              SZRT = SZL(II)
        GO TO 1110
COMMENT - UNIFORM STIFFNESS SECTION SET STIFFNESS ON RIGHT EQUAL TO
COMMENT - STIFFNESS ON LEFT
 1100         FRT = FLT
              AERT = AELT
              SXRT = SXLT
              SYRT = SYLT
              SZRT = SZLT
 1110   CONTINUE
        IF  (ICOUNT .NE. 0 ) GO TO 1210
COMMENT - FIRST SECTION OF MEMBERS STIFFNESS DATA
              ICOUNT = 1
              I1 = 2
              X1 = TH
        GO TO 1250
 1210   CONTINUE
              I1 = I2 + 1
              X1 = TH - X2
 1250   CONTINUE
        IF (XR .NE. ZL) GO TO 1260
COMMENT - LAST SECTION OF MEMBERS STIFFNESS DATA
              I2 = MP1
              X2 = 0.0
        GO TO 1270
 1260         ZI2 = XR/TH + 1.0
              I2 = ZI2
              X2 = XR - I2*TH + TH
 1270         NQ = I2 - I1
COMMENT - SUBROUTINE LINSTF DISTRIBUTES F AND AE
     CALL       LINSTF ( FLT, FRT, F, FTT2, L1 )
     CALL       LINSTF (AELT, AERT, AE, AETT2, L1 )
COMMENT - SUBROUTINE LINLD DISTRIBUTES SX,SY,SZ, QX,QY, AND QZ
        IF (SXLT .EQ. 0.0 .AND. SXRT .EQ. 0.0) GO TO 1280
     CALL       LINLD ( SXLT, SXRT, SX, L1 )
 1280   IF (SYLT .EQ. 0.0 .AND. SYRT .EQ. 0.0) GO TO 1290
     CALL       LINLD ( SYLT, SYRT, SY, L1 )
 1290   IF (SZLT .EQ. 0.0 .AND. SZRT .EQ. 0.0) GO TO 1330
     CALL       LINLD ( SZLT, SZRT, SZ, L1 )
 1330   CONTINUE
              X2L = X2
COMMENT - RETURN FOR IMAGE OF NEXT DATA CARD IF II LESS THAN NC52T
 9000   IF (II .LT. NC52T) GO TO 1050
 9900   CONTINUE
     RETURN
     END


 *********************************** SUBROUTINE ***********************************
     SUBROUTINE LINSTF (STL,STR,ST,STT2,L1)
COMMENT - SUBROUTINE LINSTIFF DISCRESTIZES LINEAR VARIATIONS IN LINEAR
COMMENT - STIFNESS PROPERTIES F( ) AND AE( )
     IMPLICIT REAL*8 (A-H,O-Z)
     DIMENSION ST(I1)
     COMMON /BLK2/ XL,XR,X1,X2,           H,TH,HSQ,HCU,X2L,I1,I2,NQ
        IF ( XL .NE. 0.0 ) GO TO 1150
COMMENT - FIRST SECTION OF MEMBER
              X2L = 0.0
              STT2 = 1.0
 1150   CONTINUE
        IF ( STR .EQ. STL ) GO TO 1310
COMMENT - LINEAR STIFFNESS SECTION
COMMENT - CALCULATE SLOPE OF LINEAR STIFFNESS VARIATION
              DS = (STR - STL)/(XR-XL)
COMMENT - FIRST ELEMENT (TH LONG) OF SECTION
COMMENT - COMPUTE EFFECTIVE STIFFNESS OF ELEMENT CONSIDERING JUMP AT
COMMENT - START OF SECTION
              STA = STL
              STB = STL + DS*X1
              STT1 = 0.5*(STA + STB)
              ST(I1) = (TH*STT1*STT2)/(X2L*STT1 + X1*STT2)
        IF (NQ .EQ. 0 ) GO TO 1250
              I1P1 = I1 + 1
              I1PNQ = I1 + NQ
COMMENT - REMAINING NQ ELEMENTS
COMMENT - COMPUTE STIFFNESS AT MID POINT OF ELEMENT
        DO 1210 I  = I1P1, I1PNQ
              STA = STB
              STB = STA + DS*TH
 1210         ST(I) = 0.5*(STA + STB)
 1250   CONTINUE
              STA = STB
              STB = STR
              STT2 = 0.5*(STA + STB)
 1290   GO TO 1800
COMMENT - UNIFORM STIFFNESS SECTION
COMMENT - FIRST ELEMENT (TH LONG) OF SECTION
COMMENT - COMPUTE EFFECTIVE STIFFNESS OF ELEMENT CONSIDERING JUMP AT
COMMENT - START OF SECTION
 1310         STT1 = STL
              ST(I1) = (TH*STT1*STT2)/(X2L*STT1 + X1*STT2)
        IF (NQ .EQ. 0 ) GO TO 1360
              I1P1 = I1 + 1
              I1PNQ = I1 + NQ
COMMENT - REMAINING NQ ELEMENTS HAVE CONSTANT STIFFNESS
        DO 1350 I  = I1P1, I1PNQ
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 1350          ST(I)  = SIL
 1360          STT2 = STL
 1800     CONTINUE
      RETURN
      END


 *********************************** SUBROUTINE ***********************************
      SUBROUTINE LINLD   ( QL, QR, Q,L1)
COMMENT - SUBROUTINE LINLD DISTRIBUTES SX, SY, SZ, QX, QY, AND QZ
      IMPLICIT REAL*8 (A-H,O-Z)
      DIMENSION Q(L1)
      COMMON /BLK2/ XL,XR,X1,X2,          H,TH,HSQ,HCU,X2L,I1,I2,NQ
COMMENT -COMPUTE SLOPE OF LINEAR VARIATION
               DQ = (QR - QL)/(XR - XL)
COMMENT - COMPUTE CONCENTRATED LOAD OR RESTRAINT FOR ELEMENT AT RIGHT
COMMENT - END OF SECTION QI, DISTANCE TO LINE OF ACTION Z AND CALL
COMMENT - CONLD TO DISTRIBUTE TO ADJACENT STATIONS
               Q2 = QR
               Q1 = QR - DQ*X2
               QC = Q1 + Q2
         IF ( QC .LT. 0.0 ) QC = -QC
         IF ( QC            .LE. 1.0E-10 ) GO TO 1005
               Z = XR - X2 + (X2/3.0)*(2.0*Q2 + Q1)/(Q1 + Q2)
               QI = 0.5*X2*(Q1 + Q2)
               QC = QI
         IF ( QC .LT. 0.0 ) QC = -QC
         IF ( QC           .LE. 1.0E-10 ) GO TO 1005
      CALL        CONLD   ( QI, Z,  Q, L1 )
COMMENT - SAME AS ABOVE FOR ELEMENT AT LEFT END OF SECTION
 1005          Q1 = QL
               Q2 = QL + DQ*X1
               QC = Q1 + Q2
         IF ( QC .LT. 0.0 ) QC = -QC
         IF ( QC            .LE. 1.0E-10 ) GO TO 1009
               Z = XL + (X1/3.0)*(2.0*Q2 + Q1)/(Q1 + Q2)
               QI = 0.5*X1*(Q1 + Q2)
               QC = QI
         IF ( QC .LT. 0.0 ) QC = -QC
         IF ( QC          .LE. 1.0E-10 ) GO TO 1009
      CALL        CONLD   ( QI, Z,  Q, L1 )
 1009    IF ( NQ .EQ. 0 ) GO TO 2000
 1020          XX = XL + X1
COMMENT - SAME AS ABOVE FOR REMAINING NQ ELEMENTS
         DO 1990 II = 1,NQ
               Q1 = Q2
               Q2 = Q1 + DQ*TH
               QC = Q1 + Q2
         IF ( QC .LT. 0.0 ) QC = -QC
         IF ( QC            .LE. 1.0E-10) GO TO 1990
               Z = XX + (TH/3.0)*(2.0*Q2 + Q1)/(Q1 + Q2)
               XX = XX + TH
               QI = 0.5*TH*(Q1 + Q2)
      CALL        CONLD   ( QI, Z,  Q, L1 )
 1990     CONTINUE
 2000     CONTINUE
      RETURN
      END


 *********************************** SUBROUTINE ***********************************
      SUBROUTINE CONLD   ( QI, Z, QO, L1)
COMMENT - SUBROUTINE CONLD DISTRIBUTES CONCENTRATED VALUE OF LOADS,
COMMENT - SPRING, STIFFNESSES, AND RESISTIVE SPRING FORCES TO ADJACENT
COMMENT - STATIONS I AND IP1
      IMPLICIT REAL*8 (A-H,O-Z)
      DIMENSION QO(L1)
      COMMON /BLK2/ XL,XR,X1,X2,          H,TH,HSQ,HCU,X2L,I1,I2,NQ
               ZI = Z/TH  + 1.0
               I = ZI
               ZZ = Z - I*TH + TH
               IP1 = I + 1
               QO(I) = QO(I) + QI*(TH - ZZ)/TH
               QO(IP1) = QO(IP1) + QI*ZZ/TH
      RETURN
      END


 *********************************** SUBROUTINE ***********************************
      SUBROUTINE NLSS ( L1, JJ )
COMMENT - SUBROUTINE NLSS DISCRETIZES DISTRIBUTED MEMBER Q - W CURVES
COMMENT - TO STATION VALUES OF RESISTIVE SPRING FORCES  SQX, SQY, SQZ
COMMENT - AND SPRING STIFFNESS  SX, SY, SZ
      IMPLICIT REAL*8 (A-H,O-Z)
      DIMENSION DC(3,3),DCT(3,3),WT(3),WTT(3),FT(3),FTT(3)
      COMMON /BLOCK2/ DXS( 25),    DYS( 25),    ZLS( 25),    DC1S( 25),
     2    DC2S( 25),  PRF( 25),    PRAE( 25),   QM( 25),     WM( 25),
     3    PRAG(25),   ELEMN(25),
     4    IOPOP( 25), IPINL( 25),  IPINR( 25),  NC51( 25),   INLOP( 25),
     5    NAL( 25),   NSXL( 25),   NSYL( 25),   NSZL( 25),   NAR( 25),
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     6      NSXR( 25),   NSYR( 25),   NSZR( 25),   NCDS( 25),   IAXOPS( 25)
      COMMON /BLOCK7/ F( 22),       AE( 22),     SX( 22),      SY( 22),
     2      SZ( 22),     QX( 22),     QY( 22),     QZ( 22),      DX( 22),
     3      DY( 22),     DZ( 22),     ERX( 22),    ERY( 22),     ERZ( 22),
     4      SQX( 22),    SQY( 22),    SQZ( 22),    U1( 22),      V1( 22),
     5      W1( 22),     U2( 22),     V2( 22),     W2( 22),      DS(3,3, 22),
     6      BM1S( 22),   BM2S( 22),   TTS( 22),    AG( 22)
      COMMON /BLK1/  TOL,    ELEMNT,NJST,   KEEP3C,NCD3C,
     2          KEEP2, KEEP3A,KEEP3B,KEEP4A,KEEP4B,KEEP4C,KEEP5A,
     3          KEEP5B,KEEP5C,KEEP5D,KEEP6, KEEP7, NCD2,  NCD3A,
     4          NCD3B, NCD4A, NCD4B, NCD4C, NCD5A, NCD5B, NCD5C,
     5          NCD5D, NCD6,  NCD7,  IP8,   IP9,   IP10,  ITYPE,
     6          IABAN, IFORM, NM,    NJT,   NST,   NLT,   M,
     7          MP1,   MP2,   ISTT,  LTT,   ITYPEL,IDJ,   NSTL
      COMMON /SKT5/       WRXM (21,10),  WRYM (21,10),  WRZM (21,10),
     2                    WRTXM(21,10),  WRTYM(21,10),  WRTZM(21,10)
            IAXOPT = IAXOPS(ISTT)
         IF (IAXOPT .EQ. 1) GO TC 2100
COMMENT - TRANSFORM MEMBER DISP TC STRUCT COORD FOR IAXOPT = 2
            DC (1,3) = 0.0
            DC (2,3) = 0.0
            DC (3,1) = 0.0
            DC (3,2) = 0.0
            DCT (1,3) = 0.0
            DCT (2,3) = 0.0
            DCT (3,1) = 0.0
            DCT (3,2) = 0.0
            DC (3,3) = 1.0
            DCT (3,3) = 1.0
            DC (1,1) = DC1S(ISTT)
            DC (1,2) = DC2S(ISTT)
            DC (2,1) = - DC (1,2)
            DC (2,2) = DC (1,1)
            DCT (1,1) = DC (1,1)
            DCT (1,2) = DC (2,1)
            DCT (2,1) = DC (1,2)
            DCT (2,2) = DC (2,2)
            WT (3) = 0.0
            FT (3) = 0.0
         DO 1300  I = 1,MP1
COMMENT - F AND AE USED AS TEMP STOR FOR DX AND DY ONLY IN THIS SUB
            F(I) = DX(I)
            AE(I) = DY(I)
            WT(1) = DX(I)
            WT(2) = DY(I)
      CALL MATM31 (DCT,WT,WTT)
            DX(I) = WTT(1)
            DY(I) = WTT(2)
 1300       CONTINUE
 2100       CONTINUE
COMMENT - AXIAL RESTRAINTS
         DO 2200  I = 1,MP2
            SQX(I) = 0.0
 2200       SX(I) = 0.0
         IF (NSXL(ISTT) .EQ. 0) GO TC 2300
      CALL      NLSNEW  (SX,DX,SQX,L1,NSXL(ISTT),NSXR(ISTT),QM(ISTT),
     2                  WM(ISTT), WRXM, WRTXM, JJ, 1 )
 2300       CONTINUE
         DO 3200  I = 1,MP2
            SQY(I) = 0.0
 3200       SY(I) = 0.0
         IF (NSYL(ISTT) .EQ. 0) GO TO 3300
      CALL      NLSNEW  (SY,DY,SQY,L1,NSYL(ISTT),NSYR(ISTT),QM(ISTT),
     2                  WM(ISTT), WRYM, WRTYM, JJ, 2 )
 3300       CONTINUE
COMMENT - ROTATIONAL RESTRAINTS
         DO 4200  I = 1,MP2
            SQZ(I) = 0.0
 4200       SZ(I) = 0.0
         IF (NSZL(ISTT) .EQ. 0) GO TO 4300
      CALL      NLSNEW  (SZ,DZ,SQZ,L1,NSZL(ISTT),NSZR(ISTT),QM(ISTT),
     2                  WM(ISTT), WRZM, WRTZM, JJ, 3 )
 4300       CONTINUE
            IF (IAXOPT .EQ. 1) GO TC 5400
            DO 5100  I = 1,MP1
COMMENT - RETURN DX AND DY TO MEMBER COORD
            DX(I) = F(I)
            DY(I) = AE(I)
COMMENT - TRANSFORM SQX AND SQY TC MEMBER COORD
            FT(1) = SQX(I)
            FT(2) = SQY(I)
      CALL MATM31 (DC,FT,FTT)
            SQX(I) = FTT(1)
            SQY(I) = FTT(2)
 5100 CONTINUE
 5400 CONTINUE
      RETURN
      END
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*********************************** SUBROUTINE ***********************************
      SUBROUTINE NLSNEW ( SXYZ, DXYZ, SQXYZ, L1, NSL, NSR, QMT,
     2                    WMT, WRM, WRTM, JJ, MCXYZ )
COMMENT - SUBROUTINE NLSNEW REPLACES THE EARLIER  NLSSJR
COMMENT - SUBROUTINE NLSNEW FURNISHES THE DISCRETISED VALUES OF RESISTIV
COMMENT - SPRING FORCE AND TANGENT STIFFNESS TO NLSS FOR AXIAL, LATERAL
COMMENT - AND ROTATIONAL SPRINGS
COMMENT - NON-LINEAR LOADING , INELASTIC UNLOADING ALGORITHM IS USED
      IMPLICIT REAL * 8 (A-H,O-Z)
      DIMENSION SXYZ(L1), DXYZ(L1),SQXYZ(L1)
      DIMENSION WRM(21,10), WRTM(21,10)
      DIMENSION W(10), RMAX(10), WR(10), WRT(10)
      DIMENSION WWMI(21,10), RMAXMI(21,10), STEEP(21)
      COMMON /BLOC14/ NPTM( 20),    ISM( 20),   NQM(20,11), NWM(20,11),
     2   NQMT(11),    NWMT(11)
      COMMON /BLK1/  TOL,    ELEMNT,NJST,  KEEP3C,NCD3C,
     2        KEEP2, KEEP3A,KEEP3B,KEEP4A,KEEP4B,KEEP4C,KEEP5A,
     3        KEEP5B,KEEP5C,KEEP5D,KEEP6, KEEP7, NCD2,  NCD3A,
     4        NCD3B, NCD4A, NCD4B, NCD4C, NCD5A, NCD5B, NCD5C,
     5        NCD5D, NCD6,  NCD7,  IP8,   IP9,   IP10,  ITYPE,
     6        IABAN, IFCRM, NM,    NJT,   NST,   NLT,   M,
     7        MP1,   MP2,   ISIT,  LTT,   ITYPEL,IDJ,   NSTL
      COMMON /BLK2/ XL,XE,X1,X2,           H,TH,HSQ,HCU,X2L,I1,I2,NQ
      COMMON /BLK7/ INLOPT,IFAE,KOFFJ,KOFFQW,KOFFSE
             KOFFQW = 0
COMMENT - KOFFQW = 0  IN EFFECT SETS NO LIMIT ON DEFORMATION
             ISYM = ISM(NSL)
             NPT = NPTM(NSL)
             NPTM1 = NPT - 1
COMMENT - SUBROUTINE MEMCUR UTILISES THE MEMBER-SUPPORT CURVES
COMMENT - AT THE ENDS OF THE MEMBER TO CREATE (LINEARLY INTERPOLATED)
COMMENT - THE EQUIVALENT SPRING AT THE CENTRE OF EACH OF THE ELEMENTS
      CALL MEMCUR ( NSL, NSR, QMT, WMT, M, TH, WWMI, RMAXMI, STEEP )
COMMENT - DO FOR EACH ELEMENT
         DO 2600 I = 2 , MP1
         DO 1300 J = 1 , NPTM1
             W(J)    = WWMI(I,J)
             RMAX(J)= RMAXMI(I,J)
             WR(J)   = WRM(I,J)
             WRT(J)  = WRTM(I,J)
 1300 CONTINUE
             SLPMAX = STEEP(I)
COMMENT - COMPUTE DISPLACEMENT AT MID-ELEMENT AS AVERAGE OF ADJACENT
COMMENT - STATION (NODAL POINT) DISPLACEMENTS
             WJ = 0.5 * ( DXYZ(I-1) + DXYZ(I) )
COMMENT - CALL  CURNEW  TO FIND RESISTIVE FORCE AND TANGENT STIFFNESS
      CALL CURNEW ( NPT, W, RMAX, WJ, QJ, S2, WR, WRT,         SLPMAX,
     2              I, MCXYZ )
         DO 1400 J = 1 , NPTM1
             WRM(I,J) = WR(J)
             WRTM(I,J) = WRT(J)
 1400 CONTINUE
             SQXYZ(I-1) = SQXYZ(I-1) + 0.5 * QJ
             SQXYZ(I  ) = SQXYZ(I  ) + 0.5 * QJ
             SXYZ (I-1) = SXYZ (I-1) + 0.5 * S2
             SXYZ (I  ) = SXYZ (I  ) + 0.5 * S2
 2600 CONTINUE
      RETURN
      END
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*********************************** SUBROUTINE ***********************************
      SUBROUTINE MEMCUR (NSL,NSR,QMT,WMT,M,TH,WWMI,RMAXMI,STEEP )
COMMENT - SUBROUTINE MEMCUR UTILISES THE MEMBER-SUPPORT CURVES
COMMENT - AT THE ENDS OF THE MEMBER TO CREATE (LINEARLY INTERPOLATED)
COMMENT - THE EQUIVALENT SPRING AT THE CENTRE OF EACH OF THE ELEMENTS
      IMPLICIT REAL * 8 (A-H,O-Z)
      COMMON /BLOC14/ NPTM( 20),    ISM( 20),   NQM(20,11), NWM(20,11),
     2   NQMT(11),    NWMT(11)
      DIMENSION QQ(11),WW(11),RMAX(10),QQL(11),WWL(11),QQR(11),WWR(11)
      DIMENSION WWMI(21,10), RMAXMI(21,10), STEEP(21)
             NPT = NPTM(NSL)
         DO 110 J = 1,NPT
             QQL(J) = NQM(NSL,J)
             WWL(J) = NWM(NSL,J)
             QQR(J) = NQM(NSR,J)
             WWR(J) = NWM(NSR,J)
  110    CONTINUE
             AM = M
             MP1 = M + 1
         DO 1000 I = 2,MP1
             AI = I
             ALPHA = ( AI - 1.5 ) / AM
         DO 150 J = 1,NPT
             QQ(J) = (QQL(J) + ALPHA*(QQR(J)-QQL(J)) ) * QMT * TH
             WW(J) = (WWL(J) + ALPHA*(WWR(J)-WWL(J)) ) * WMT
  150    CONTINUE
             STEEP(I) = QQ(2) / WW(2)
             NPTM2 = NPT - 2
             NPTM1 = NPT - 1
         IF ( NPTM2 .EQ. 0 ) GO TO 205
         DO 200 J = 1 , NPTM2
             SLOK = ( QQ(J+1)-QQ(J) ) / ( WW(J+1)-WW(J) )
             SLOKP1 = ( QQ(J+2)-QQ(J+1) ) / ( WW(J+2)-WW(J+1) )
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               STF = SLOK - SLOKP1
               RMAX(J) = WW(J+1) * STF
  200 CONTINUE
  205 CCNTINUE
               STF = ( QQ(NPT)-QQ(NPTM1) ) / ( WW(NPT)-WW(NPTM1) )
               RMAX(NPTM1) = WW(NPT) * STF
         DO 220 J = 1 , NPTM1
               WWMI(I,J)  = WW(J+1)
               RMAXMI(I,J) = RMAX(J)
  220 CONTINUE
 1000      CONTINUE
      RETUEN
      END


************************************ SUBROUTINE **********************************
      SUBROUTINE CURNEW ( NPT, W, RMAX, U, R, BK, UR, URT,          SLPMAX
     2                   ,I, MCXYZ )
COMMENT - SUBROUTINE CURNEW USES MASING MODEL TO OBTAIN RESISTIVE FORCE
COMMENT - AND TANGENT STIFFNESS FOR INELASTIC MEMBER SUPPORT CURVES.
      IMPLICIT REAL*8 (A-H,O-Z)
      DIMENSION W(10), RMAX(10), UR(10), URT(10)
      COMMON /BLK1/  TOL,     ELEMNT,NJST,   KEEP3C,NCD3C,
     2               KEEP2, KEEP3A,KEEP3B,KEEP4A,KEEP4B,KEEP4C,KEEP5A,
     3               KEEP5B,KEEP5C,KEEP5D,KEEP6, KEEP7, NCD2,  NCD3A,
     4               NCD3B, NCD4A, NCD4B, NCD4C, NCD5A, NCD5B, NCD5C,
     5               NCD5D, NCD6,  NCD7,  IP8,   IP9,   IP10,  ITYPE,
     6               IABAN, IFORM, NM,    NJT,   NST,   NLT,   M,
     7               MP1,   MP2,   ISTT,  LTT,   ITYPEL,IDJ,   NSTL
      COMMON /BLK5/ NFSUB,NITF,N1,N2
      COMMON /BLK7/ INLOPT,IFAE,KCFFJ,KOFFQW,KOFFSE
      COMMON /SKT6/        NITERM(50), INDEX
      COMMON /SKT14 / IRV(21,2,10),                    FOMOLD(50,6),
     2               IRVRSE,        ITAPE,             N3
      COMMON /SKT15/ JJ
      COMMON /SKT18/ NCHECK
      COMMON /SKT20/ MCRGON(21,3), MCUREV(21,3)
      COMMON /SKT22/ TIME, JT, IRDYN, IRSTEP(71)
COMMENT - IN THIS SUBROUTINE, IT SHOULD BE NOTED THAT THE RESISTANCE
COMMENT - AXIS HAS A NEGATIVE MULTIPLIER AS INPUT. HENCE PROPER
COMMENT - CARE IS TAKEN TO ACCOUNT FOR THIS . COMPARE & CONTRAST
COMMENT - WITH SUBROUTINE  MASING ( STRESS-STRAIN ROUTINE )
               NPTM1 = NPT - 1
               R = 0.0
               BK = 0.0
         DO 2200 K = 1,NPTM1
               STIFF = RMAX(K) / W(K)
         IF ( DABS  ( U - UR(K) ) .GE. ( W(K) - 5.0D-10) ) GO TO 1500
               BK = BK - STIFF
               Z = STIFF * ( U - UR(K) )
         IF ( NCHECK .NE. 1 ) GO TO 1450
         IF ( K      .NE. 1 ) GO TC 1450
         IF ( MCRGON(I,MCXYZ) .EQ. 0 ) GO TO 1450
               MCUREV (I,MCXYZ) = 1
         GO TO 2000
 1450    CONTINUE
               URT(K) = UR(K)
         IF ( IFAE .EQ. 1 ) GO TO 1460
         IF ( K     .NE. 1 ) GO TO 1460
               MCRGCN(I,MCXYZ) =  0
 1460    CONTINUE
         GC TO 2000
 1500 CONTINUE
        IF ( U .GT. UR(K) ) GO TC 1600
               Z = - RMAX(K)
         IF ( NCHECK .NE. 1 ) GO TO 1550
         IF ( K      .NE. 1 ) GO TO 1550
         IF ( MCRGCN(I,MCXYZ) .NE. 1 ) GO TO 1550
               MCUREV (I,MCXYZ) = 1
         GC TO 2000
 1550    CONTINUE
               URT(K) = U + W(K)
         IF ( IFAE .EQ. 1 ) GO TC 1560
         IF ( K     .NE. 1 ) GO TC 1560
               MCRGON(I,MCXYZ) = -1
 1560    CONTINUE
         GO TO 2000
 1600 CONTINUE
               Z = RMAX(K)
         IF ( NCHECK .NE. 1 ) GO TO 1650
         IF ( K      .NE. 1 ) GO TO 1650
         IF ( MCRGCN(I,MCXYZ) .NE.-1 ) GO TC 1650
               MCUREV (I,MCXYZ) = 1
         GO TO 2000
 1650    CONTINUE
               URT(K) = U - W(K)
         IF ( IFAE .EQ. 1 ) GO TO 1660
         IF ( K     .NE. 1 ) GO TC 1660
               MCRGON(I,MCXYZ) = +1
 1660    CONTINUE
 2000    CONTINUE
               R = R + Z
 2200    CONTINUE
         IF ( ITYPE .GE. 3 ) GC TO 2210
```

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      IF ( IFAE  .EQ. 1 ) GO TO 2220
      IF ( NITF  .EQ. 2 .AND. NITERM(JJ) .EQ. 1 ) GO TO 2220
      GO TO 2250
2210  CONTINUE
      IF ( IRDYN .EQ. 1 ) GO TO 2220
     IF(IRSTEP(JT).EQ.1.AND.NITF.EQ.1.AND.NITERM(JJ).EQ.1)GO TO 2220
      GO TO 2250
2220  CONTINUE
      IF ( MCUREV(I,MCXYZ) .EQ. 0 ) GO TO 2250
        BK = - SLPMAX
      IF ( ITYPE .LE. 2 ) GO TO 2240
      IF ( IRDYN .EQ. 1 ) GO TO 2250
     IF(IRSTEP(JT).EQ.1.AND.NITF.EQ.1.AND.NITERM(JJ).EQ.1)
     2   MCUREV(I,MCXYZ) = 0
      GO TO 2250
2240  CONTINUE
      IF ( IFAE .EQ. 0 ) MCUREV(I,MCXYZ) = 0
2250  CONTINUE
      IF ( NCHECK .NE. 1 ) GO TO 2800
        IRVRSE = IRVRSE + MCUREV(I,MCXYZ)
2800  CONTINUE
      RETURN
      END


************************************ SUBROUTINE ************************************
      SUBROUTINE GRIP2A (C,B,X,SL,L3,L4,L6,M)
COMMENT - SUBROUTINE GRIP2A UTILIZES GAUSS ELIMINATION METHOD TO SOLVE
COMMENT - FOR MEMBER AND JOINT SOLUTIONS.
      IMPLICIT REAL*8 (A-H,O-Z)
      DIMENSION C(L6,L4),B(L6),X(L6)
      COMMON /BLK5/ NFSUB,NITF,N1,N2
      COMMON /BI/ NL,ML,J1
      COMMON /SKT15/  JJ
  888 FORMAT (///,30H FAILURE IN SOLUTION OF MEMBER,I4,/,
     2  6H DOF =,I5,/, 8H COEFF =,1PE13.6,//)
  999 FORMAT (///,27H FAILURE IN JOINT SOLUTION,/,
     2  6H DOF =,I5,/, 8H COEFF =,1PE13.6,//)
        KEY=ML
        N=NL
      CALL FSUB1 (C,B,X,L3,L4,L6,M)
COMMENT - FORWARD ELIMINATION
        NM1 = N - 1
      DO 98 J = 1,NM1
        JM=J+M
      IF (JM .GT. N) JM=N

        JP1=J+1
        MM=M+1
      IF (M+J .GT. N) MM=N-J+1
      DO 97 K=JP1,JM
        KK=K-JP1+2
      IF (C(J,1).GT.0.0    ) GO TO 50
      IF ( NFSUB .EQ. 22 ) GO TO 30
      PRINT 999,J, C(J,1)
      GO TO 40
   30 CONTINUE
      PRINT 888, JJ, J, C(J,1)
   40 CONTINUE
      M=10001
      GO TO 195
   50 COEFF=-C(J,KK)/C(J,1)
        B(K)=B(K)+COEFF*B(J)
        MM=MM-1
      IF (KEY .EQ. -1) GO TO 97
      DO 96 I=1,MM
        II=I+K-J
        C(K,I)=C(K,I)+COEFF*C(J,II)
   96 CONTINUE
   97 CONTINUE
   98 CONTINUE
COMMENT - BACK SUBSTITUTION
      IF (C(N,1).GT.0.0    ) GO TO 110
      IF ( NFSUB .EQ. 22 ) GO TO 100
      PRINT 999,N, C(N,1)
      GO TO 105
  100 CONTINUE
      PRINT 888, JJ, N, C(N,1)
  105 CONTINUE
      M=10001
      GO TO 195
  110   X(N)=B(N)/C(N,1)
        NM=0
      DO 190 KK=2,N
        K=N-KK+1
      IF (KK .GT. M) GO TC 150
        NM=NM+1
      GO TO 160
  150   NM=M
  160   X(K)=B(K)
        NN1 = 1
        NN2 = K
      DO 170 II=1,NM
        NN1 = NN1 + 1
        NN2 = NN2 + 1
```

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          X(K) = X(K) - C(K,NN1) * X(NN2)
 170      CONTINUE
          X(K) =X(K)/C(K,1)
 190 CONTINUE
 195 CCNTINUE
     RETURN
     END


***************************************** SUBROUTINE ****************************************
      SUBROUTINE FSUB1 (RM,RO,W,L3,L4,L6,M)
COMMENT - FSUB1 CALLS FSUB2, FOR FRAME SOLUTIONS AND FSUB22 FOR MEMBER
COMMENT - SOLUTIONS
      IMPLICIT REAL*8 (A-H,O-Z)
      DIMENSION RM(L6,L4),RO(L6),W(L6)
      COMMON /RI/ NL,ML,J1
      COMMON /BLK5/ NFSUB,NITF,N1,N2
          IF (NFSUB .EQ. 21) CALL FSUB21 (RM, RO, L6, L4, M)
          IF (NFSUB .EQ. 23) CALL FSUB23 (RM, RO, L6, L4, M)
          IF (NFSUB .EQ. 22) CALL FSUB22 (RM, RO, L6, L4)
      RETURN
      END


***************************************** SUBROUTINE ****************************************
      SUBROUTINE FSUB21 ( RM, RO, L6, L4, IHB )
COMMENT - SUBROUTINE FSUB21 FURNISHES RIGHT SIDE OF SYMMETRIC STIFFNESS
COMMENT - MATRIX RM AND LCAD MATRIX RO
      IMPLICIT REAL*8 (A-H,O-Z)
      DIMENSION RM(L6,L4),RO(L6)
      DIMENSION SMM(3,3),SMS(3,3),DC(3,3),DCT(3,3),T33(3,3),
    2 FMM(3),FSS(3),FMS(3)
      COMMON /BLOCK1/ X(25),        Y(25),        QXX(25),      QYY(25),
    2      QZZ(25),      SXX(25),      SYY(25),      SZZ(25),      DXX(25),
    3      DYY(25),      DZZ(25),      RXX(25),      RYY(25),      RZZ(25),
    4      ERXX(25),     ERYY(25),     ERZZ(25),     QMJ(25),      WMJ(25),
    5      NSXX(25),     NSYY(25),     NSZZ(25),     IMJ(25),      NSXP(25),
    6      NSYP(25),     ISTJR(25)
      COMMON /BALA01/ QVV(25),      SVV(25),      DVV(25),      ERVV(25),
    2      RVV(25),      NSVV(25)
      COMMON /BLOCK2/ DXS( 25),     DYS( 25),     ZLS( 25),     DC1S( 25),
    2      DC2S( 25),    PRF( 25),     PRAE( 25),    QM( 25),      WM( 25),
    3      PRAG(25),     ELEMN(25),
    4      IOPOP( 25),   IPINL( 25),   IPINR( 25),   NC51( 25),    INLOP( 25),
    5      NAL( 25),     NSXL( 25),    NSYL( 25),    NSZL( 25),    NAR( 25),
    6      NSXR( 25),    NSYR( 25),    NSZR( 25),    NCDS( 25),    IAXOPS( 25)
      COMMON /BLOCK3/ DXL( 25),     DYL( 25),     ZLL( 25),     DC1L( 25),
    2      DC2L( 25),    UQX( 25),     UQY( 25),     NCDL( 25),    IAXCPL( 25),
    3      NC61( 25),    IOVRM(25)
      COMMON /BLOCK4/ FOMM(50,6),SMC(50,21),IST(50),   LT(50),
    2      JT1(50),      JT2(50),         NITM(50),     IMM(50),      IMC(50)
      COMMON /BLOC10/ SSL(4,24)
      COMMON /BLK1/  TOL,    ELEMNT, NJST,   KEEP3C, NCD3C,
    2             KEEP2,  KEEP3A, KEEP3B, KEEP4A, KEEP4B, KEEP4C, KEEP5A,
    3             KEEP5B, KEEP5C, KEEP5D, KEEP6,  KEEP7,  NCD2,   NCD3A,
    4             NCD3B,  NCD4A,  NCD4B,  NCD4C,  NCD5A,  NCD5B,  NCD5C,
    5             NCD5D,  NCD6,   NCD7,   IP8,    IP9,    IP10,   ITYPE,
    6             IABAN,  IFORM,  NM,     NJT,    NST,    NLT,    M,
    7             MP1,    MP2,    ISTT,   LTT,    ITYPEL, IDJ,    NSTL
      COMMON /BLK5/ NFSUB,NITF,N1,N2
      COMMON / RI / NL, ML, J1
      COMMON /NIT/ APROB
      COMMON /SKT14 / IRV(21,2,10),                     FOMOLD(50,6),
    2                 IRVESE,        ITAPE,             N3
      COMMON /SKT16/      ERXXOL(25),ERYYOL(25),ERZZOL(25),ERVVOL(25)
 4750 FORMAT ( 1X, 10(1PE13.5) )
          DATA PRINT /4HRINT/
              NL4 = NL
              ML4 = ML
          DO 6000 JTN=1,NJT
          IF (JTN .NE. 1 )  GO TO 1300
COMMENT - SET CONSTANTS ON FIRST CALL FROM GRIP2A
              IHBP1 = IHB + 1
              IHB1 = IHB - 1
              DC(1,3) = 0.0
              DC(2,3) = 0.0
              DC(3,1) = 0.0
              DC(3,2) = 0.0
              DCT(1,3) = 0.0
              DCT(2,3) = 0.0
              DCT(3,1) = 0.0
              DCT(3,2) = 0.0
              DC(3,3) = 1.0
              DCT(3,3) = 1.0
COMMENT - COMPUTE THE EQUATION NUMBER
 1300         J1 = 3*JTN-2
COMMENT - ZERO SSL AND FSS
          DO 1400 I = 1, 3
          DO 1400 J = 1,IHBP1
 1400         SSL(I,J) = 0.0
              FSS(1) = 0.0
              FSS(2) = 0.0
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                FSS(3) = 0.0
COMMENT - DO FOR EACH MEMBER - ADD ITS STIFFNESS MATRIX AND LOAD MATRIX
COMMENT - INTO STRUCTURE STIFFNESS MATRIX SSL AND LOAD MATRIX FSS
          DO 3500  JJ = 1,NM
          IF  ( JT1(JJ) .NE. JTN .AND. JT2(JJ) .NE. JTN )  GO TO 3500
              ISTT = IST(JJ)
COMMENT - SKIP FOR NULL MEMBER
          IF ( ISTT .EQ. 0 ) GO TO 3500
COMMENT - FORM TRANSFORMATION MATRIX AND ITS TRANSPOSE
                DC(1,1) = DC1S(ISTT)
                DC(1,2) = DC2S(ISTT)
                DC(2,1) = - DC(1,2)
                DC(2,2) = DC(1,1)
                DCT(1,1) = DC(1,1)
                DCT(1,2) = DC(2,1)
                DCT(2,1) = DC(1,2)
                DCT(2,2) = DC(2,2)
          IF ( JT2(JJ) .EQ. JTN ) GO TO 2300
COMMENT - FORM SMM FOR MEMBER WITH FROM JOINT AT JOINT JTN
                SMM(1,1) = SMC(JJ,1)
                SMM(1,2) = SMC(JJ,2)
                SMM(1,3) = SMC(JJ,3)
                SMM(2,1) = SMC(JJ,2)
                SMM(2,2) = SMC(JJ,7)
                SMM(2,3) = SMC(JJ,8)
                SMM(3,1) = SMC(JJ,3)
                SMM(3,2) = SMC(JJ,8)
                SMM(3,3) = SMC(JJ,12)
COMMENT - FORM FMM FOR MEMBER WITH FROM JOINT AT JOINT JTN
 2250           FMM(1) =  FOMM(JJ,1)
                FMM(2) =  FOMM(JJ,2)
                FMM(3) =  FOMM(JJ,3)
          GO TO 2500
 2300     CONTINUE
COMMENT - FORM SMM FOR MEMBER WITH  TO  JOINT AT JOINT JTN
                SMM(1,1) = SMC(JJ,16)
                SMM(1,2) = SMC(JJ,17)
                SMM(1,3) = SMC(JJ,18)
                SMM(2,1) = SMC(JJ,17)
                SMM(2,2) = SMC(JJ,19)
                SMM(2,3) = SMC(JJ,20)
                SMM(3,1) = SMC(JJ,18)
                SMM(3,2) = SMC(JJ,20)
                SMM(3,3) = SMC(JJ,21)
COMMENT - FORM FMM FOR MEMBER WITH  TO  JOINT AT JOINT JTN
 2350           FMM(1) =  FOMM(JJ,4)
                FMM(2) =  FOMM(JJ,5)
                FMM(3) =  FOMM(JJ,6)
 2500     CONTINUE
COMMENT - TRANSFORM SMM AND FMM TO STRUCTURE COORDINATES SMS AND FMS
      CALL MATM33  ( DCT, SMM, T33)
      CALL MATM33  ( T33, DC,  SMS)
 2550 CALL MATM31  ( DCT, FMM, FMS)
COMMENT - ADD (SUBTRACT) IN FMS TO STRUCTURE LOAD MATRIX FSS
                FSS(1) = FSS(1) - FMS(1)
                FSS(2) = FSS(2) - FMS(2)
                FSS(3) = FSS(3) - FMS(3)
COMMENT - ADD IN SMS TO DIAGONAL SUBMATRIX OF SSL - SYMMETRICAL TERMS
                SSL(1,1) = SSL(1,1)  +  SMS(1,1)
                SSL(1,2) = SSL(1,2)  +  SMS(1,2)
                SSL(1,3) = SSL(1,3)  +  SMS(1,3)
                SSL(2,2) = SSL(2,2)  +  SMS(2,2)
                SSL(2,3) = SSL(2,3)  +  SMS(2,3)
                SSL(3,3) = SSL(3,3)  +  SMS(3,3)
COMMENT - SKIP FOR SMM WHICH ARE TO LEFT OF DIAGONAL
          IF ( JTN .GE. JT1(JJ) .AND. JTN .GE. JT2(JJ) ) GO TO 3500
          IF ( JT2(JJ) .EQ. JTN ) GO TO 2700
COMMENT - FORM SMM FOR MEMBER WITH FROM JOINT AT JOINT JTN
                SMM(1,1) = SMC(JJ,4)
                SMM(1,2) = SMC(JJ,5)
                SMM(1,3) = SMC(JJ,6)
                SMM(2,1) = SMC(JJ,9)
                SMM(2,2) = SMC(JJ,10)
                SMM(2,3) = SMC(JJ,11)
                SMM(3,1) = SMC(JJ,13)
                SMM(3,2) = SMC(JJ,14)
                SMM(3,3) = SMC(JJ,15)
                GO TO 3000
COMMENT - FORM SMM FOR MEMBER WITH  TO  JOINT AT JOINT JTN
 2700           SMM(1,1) = SMC(JJ,4)
                SMM(1,2) = SMC(JJ,9)
                SMM(1,3) = SMC(JJ,13)
                SMM(2,1) = SMC(JJ,5)
                SMM(2,2) = SMC(JJ,10)
                SMM(2,3) = SMC(JJ,14)
                SMM(3,1) = SMC(JJ,6)
                SMM(3,2) = SMC(JJ,11)
                SMM(3,3) = SMC(JJ,15)
 3000     CONTINUE
COMMENT - TRANSFORM SMM TO STRUCTURE COORDINATES SMS
      CALL        MATM33 ( DCT, SMM, T33 )
      CALL        MATM33 ( T33, DC, SMS )
COMMENT - PLACE SMS IN SSL
                J21 =        JT2(JJ) - JT1(JJ)
                J21 = IABS(J21)
                ISTP = 3*J21 + 1
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                SSL(1,ISTP)       =  SMS(1,1)
                SSL(1,ISTP + 1)   =  SMS(1,2)
                SSL(1,ISTP + 2)   =  SMS(1,3)
                SSL(2,ISTP)       =  SMS(2,1)
                SSL(2,ISTP + 1)   =  SMS(2,2)
                SSL(2,ISTP + 2)   =  SMS(2,3)
                SSL(3,ISTP)       =  SMS(3,1)
                SSL(3,ISTP + 2)   =  SMS(3,3)
                SSL(3,ISTP + 1)   =  SMS(3,2)
 3500       CONTINUE
COMMENT - CALL INELST TO FIND SPRING RESISTIVE FORCES AND TANGENT STIFF
COMMENT - NESSES  - SPRING FORCES ARE ADDED INTO LOAD MATRIX ONLY ON
COMMENT - FIRST ITERATICN FROM A ZERO DISPLACEMENT START
      CALL        INELST (JTN,SJX,SJY,SJZ,SJV,SJXY,QJX,QJY,QJZ,QJV)
COMMENT - ADD IN JCINT LOADS
            IF (NITP .EQ. 1 .AND. ITYPE .EQ. 1) GO TO 3550
                QJX = 0.0
                QJY = 0.0
                QJZ = 0.0
 3550       CONTINUE
            IF ( IRVESE .NE. 0 ) GO TO 3580
COMMENT - STORE FOR USE IF REVERSAL OCCURS LATER
                ERXXOL(JTN) = ERXX  (JTN)
                ERYYCL(JTN) = ERYY  (JTN)
                ERZZOL(JTN) = ERZZ  (JTN)
            GO TO 3590
 3580       CONTINUE
                ERXX  (JTN) = ERXXOL(JTN)
                ERYY  (JTN) = ERYYOL(JTN)
                ERZZ  (JTN) = ERZZCL(JTN)
 3590       CONTINUE
                FSS(1) = FSS(1) + ERXX(JTN) + QJX
                FSS(2) = FSS(2) + ERYY(JTN) + QJY
                FSS(3) = FSS(3) + ERZZ(JTN) + QJZ
COMMENT - ADD IN JOINT RESTRAINTS
                SSL(1,1) = SSL(1,1) + SXX(JTN) + SJX
                SSL(1,2) = SSL(1,2) + SJXY
                SSL(2,2) = SSL(2,2) + SYY(JTN) + SJY
                SSL(3,3) = SSL(3,3) + SZZ(JTN) + SJZ
            IF (ITYPE .EQ. 3) CALL ADDYN(JTN,FSS)
            IF (ITYPE .EQ. 4) CALL ADDYN(JTN,FSS)
COMMENT - SHIFT SSL TO FACILITATE OBTAINING SU FROM 2ND AND 3RD ROW
COMMENT - OF SSL
            DO 3600  I = 1,IHB
 3600           SSL(2,I) = SSL(2, I + 1)
            DO 3700  I = 1,IHB1
 3700           SSL(3,I) = SSL(3,I + 2)
                SSL(2,IHBP1) = 0.0

                SSL(3,IHBP1) = 0.0
                SSL(3,IHB)   = 0.0
 4000       CONTINUE
            DO 4500 II=1,3
            IF(SSL(II,1) .NE. 0.0) GO TO 4500
COMMENT - ZERC ON DIAGONAL MATRIX - DISPLACEMENT UNDEFINED - SET
COMMENT - DISPLACEMENT EQUAL TO 1.0E40
                SSL(II,1) = 1.0
                FSS(II) = 1.0E40
 4500       CONTINUE
            IF (APROB .NE. PRINT) GO TO 5000
COMMENT - DUMP OF STRUCTURE STIFFNESS AND LCAD MATRIX, TO ACTIVATE SET
COMMENT - LAST FIVE COLUMNS IN PRCBLEM NUMBER CARD EQUAL TO PRINT
            DO 4700 II=1,3
            PRINT 4750, (SSL(II,I),I=1,IHBP1),FSS(II)
 4700       CONTINUE
 5000       CONTINUE
                J1P1 = J1 + 1
                J1P2 = J1 + 2
            IF (ML .EQ. -1) GO TO 5200
            DO 5100 J2=1,IHBP1
                RM(J1,J2)   = SSL(1,J2)
                RM(J1P1,J2) = SSL(2,J2)
                RM(J1P2,J2) = SSL(3,J2)
 5100       CONTINUE
 5200           RO(J1)   = FSS(1)
                RO(J1P1) = FSS(2)
                RO(J1P2) = FSS(3)
 6000       CONTINUE
      RETURN
      END


************************************ SUBROUTINE ************************************
      SUBROUTINE MATM33 ( AA, BB, CC )
C        THIS SUBRCUTINE MULTIPLIES A 3X3 MATRIX ,AA, TIMES A
C        3X3 MATRIX ,BB, TO PRODUCE A 3X3 MATRIX ,CC
      IMPLICIT REAL*8 (A-H,O-Z)
      DIMENSION AA(3,3),BB(3,3),CC(3,3)
         DO 25  I = 1,3
         DO 25  J = 1,3
            CC(I,J) = 0.0
         DO 25  K = 1,3
            CC(I,J) = AA(I,K)*BB(K,J) + CC(I,J)
   25    CONTINUE
      RETURN
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      END

************************************ SUBROUTINE ************************************
      SUBROUTINE MATM31 ( AA, B,  C )
C         THIS SUBROUTINE MULTIPLIES A 3X3 MATRIX ,AA, TIMES A
C         3X1 MATRIX ,B, TO PRODUCE A 3X1 MATRIX ,C
      IMPLICIT REAL*8 (A-H,O-Z)
      DIMENSION AA(3,3),B(3),C(3)
          DO 25  I = 1,3
             C(I) = 0.0
          DO 25  K = 1,3
             C(I) =AA(I,K)*B(K) + C(I)
   25     CONTINUE
      RETURN
      END


************************************ SUBROUTINE ************************************
      SUBROUTINE INELST (JTN,SJX,SJY,SJZ,SJV,SJXY,QJX,QJY,QJZ,QJV)
COMMENT - SUBROUTINE INELST DETERMINES THE RESISTIVE SPRING FORCES
COMMENT - AND TANGENT STIFFNESSES OF ALL JOINT SPRINGS AS PER THE
COMMENT - NON-LINEAR INELASTIC LOADING-UNLOADING PATH GIVEN THE
COMMENT - DISPLACEMENTS.
COMMENT - THE SUBROUTINE ITSELF KEEPS TRACK OF THE DEFORMATION HISTORY
COMMENT - THIS SUBROUTINE INELST TOGETHER WITH SUBROUTINE  CURVIN
COMMENT - REPLACES THE PREVIOUS SUBROUTINES  JNTSPR + CURVE (OF THE
COMMENT - EARLIER VERSION  FRAM61)
      IMPLICIT REAL*8 (A-H,O-Z)
      DIMENSION W(10), RMAX(10), UR(10), URT(10)
      COMMON /BLOCK1/ X(25),        Y(25),        QXX(25),      QYY(25),
     2     QZZ(25),     SXX(25),      SYY(25),      SZZ(25),      DXX(25),
     3     DYY(25),     DZZ(25),      RXX(25),      RYY(25),      RZZ(25),
     4     ERXX(25),    ERYY(25),     ERZZ(25),     QMJ(25),      WMJ(25),
     5     NSXX(25),    NSYY(25),     NSZZ(25),     IMJ(25),      NSXP(25),
     6     NSYP(25),    ISTJR(25)
      COMMON /BALA01/ QVV(25),      SVV(25),      DVV(25),      ERVV(25),
     2     RVV(25),     NSVV(25)
      COMMON /BLOCK2/ DXS( 25),     DYS( 25),     ZLS( 25),     DC1S( 25),
     2     DC2S( 25),   PRF( 25),     PRAE( 25),    QM( 25),      WM( 25),
     3     PRAG(25),    ELEMN(25),
     4     IOPOP( 25),  IPINL( 25),   IPINR( 25),   NC51( 25),    INLOP( 25),
     5     NAL( 25),    NSXL( 25),    NSYL( 25),    NSZL( 25),    NAR( 25),
     6     NSXR( 25),   NSYR( 25),    NSZR( 25),    NCDS( 25),    IAXOPS( 25)

      COMMON /BLOCK8/ NPT( 20),     ISJ( 20),     NQJ( 20,11),NWJ( 20,11),
     2     NQJT(11),    NWJT(11)
      COMMON /BLK7/ INLOPT,IFAE,KOFFJ,KOFFCW,KOFFSE
      COMMON /SKT1/       WWJT(20,10),   RMAXJT(20,10)
      COMMON /SKT2/       WRX(25,10),  WRY(25,10),  WRZ(25,10),
     2     WRV(25,10),    WRXP(25,10), WRYP(25,10), WRTX(25,10),
     3     WRTY(25,10),   WRTZ(25,10), WRTV(25,10), WRTXP(25,10),
     4     WRTYP(25,10)
              KOFFJ = 0
COMMENT - KOFFJ = 0 IN EFFECT SETS NO LIMIT ON DEFORMATION
          IF ( NSXX(JTN) .EQ. 0 ) GO TO 3510
              NC = NSXX(JTN)
              NPTT = NPT(NC)
              NPTTM1 = NPTT-1
          DO 3509 I = 1,NPTTM1
              UR (I) = WRX (JTN,I)
              URT(I) = WRTX(JTN,I)
              W (I)  = WMJ (JTN) * WWJT  (NC,I)
              RMAX(I) = QMJ (JTN) * RMAXJT(NC,I)
 3509 CONTINUE
              TEMP1 = NQJ(NC,2)
              TEMP2 = NWJ(NC,2)
              SLPMAX = TEMP1*QMJ(JTN) / TEMP2 / WMJ(JTN)
              WJ = DXX(JTN)
       CALL CURVIN ( NPTT,W,RMAX,WJ,QJX,SJX,UR,URT,JTN,1,SLPMAX )
          DO 3400 I = 1,NPTTM1
              WRX (JTN,I) = UR (I)
              WRTX(JTN,I) = URT(I)
 3400 CONTINUE
          GO TO 3511
 3510 CONTINUE
              QJX = 0.0
              SJX = 0.0
 3511     IF ( NSYY(JTN) .EQ. 0 ) GO TO 3520
              NC = NSYY(JTN)
              NPTT = NPT(NC)
              NPTTM1 = NPTT-1
          DO 3519 I = 1,NPTTM1
              UR (I) = WRY (JTN,I)
              URT(I) = WRTY(JTN,I)
              W (I)  = WMJ (JTN) * WWJT  (NC,I)
              RMAX(I) = QMJ (JTN) * RMAXJT(NC,I)
 3519 CONTINUE
              TEMP1 = NQJ(NC,2)
              TEMP2 = NWJ(NC,2)
              SLPMAX = TEMP1*QMJ(JTN) / TEMP2 / WMJ(JTN)
              WJ = DYY(JTN)
       CALL CURVIN ( NPTT,W,RMAX,WJ,QJY,SJY,UR,URT,JTN,2,SLPMAX )
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          DO 3410 I = 1,NPTTM1
                WRY (JTN,I) = UR (I)
                WRTY(JTN,I) = URT(I)
 3410 CONTINUE
          GO TO 3521
 3520 CONTINUE
                QJY = 0.0
                SJY = 0.0
 3521     IF ( NSZZ(JTN) .EQ. 0 ) GO TO 3530
                NC = NSZZ(JTN)
                NPTT = NPT(NC)
                NPTTM1 = NPTT-1
          DO 3529 I = 1,NPTTM1
                UR  (I) = WRZ  (JTN,I)
                URT (I) = WRTZ (JTN,I)
                W  (I)  = WMJ  (JTN) * WWJT   (NC,I)
                RMAX(I) = QMJ  (JTN) * RMAXJT(NC,I)
 3529 CONTINUE
                TEMP1 = NOJ(NC,2)
                TEMP2 = NWJ(NC,2)
                SLPMAX = TEMP1*QMJ(JTN) / TEMP2 / WMJ(JTN)
                WJ = DZZ(JTN)
       CALL CURVIN ( NPTT,W,RMAX,WJ,QJZ,SJZ,UR,URT,JTN,3,SLPMAX )
          DO 3420 I = 1,NPTTM1
                WRZ  (JTN,I) = UR (I)
                WRTZ (JTN,I) = URT(I)
 3420 CONTINUE
          GO TO 3531
 3530 CONTINUE
                QJZ = 0.0
                SJZ = 0.0
 3531     IF ( NSVV(JTN) .EQ. 0 ) GO TO 3540
                NC = NSVV(JTN)
                NPTT = NPT(NC)
                NPTTM1 = NPTT-1
          DO 3539 I = 1,NPTTM1
                UR  (I) = WRV  (JTN,I)
                URT (I) = WRTV (JTN,I)
                W  (I)  = WMJ  (JTN) * WWJT   (NC,I)
                RMAX(I) = QMJ  (JTN) * RMAXJT(NC,I)
 3539 CONTINUE
                TEMP1 = NOJ(NC,2)
                TEMP2 = NWJ(NC,2)
                SLPMAX = TEMP1*QMJ(JTN) / TEMP2 / WMJ(JTN)
                WJ = DVV(JTN)
       CALL CURVIN ( NPTT,W,RMAX,WJ,QJV,SJV,UR,URT,JTN,4,SLPMAX )
          DO 3430 I = 1,NPTTM1
                WRV  (JTN,I) = UR (I)
                WRTV (JTN,I) = URT(I)
 3430 CONTINUE
          GO TO 3541
 3540 CONTINUE
                QJV = 0.0
                SJV = 0.0
 3541     IF ( NSXP(JTN) .EQ. 0) GO TO 3550
                NC = NSXP(JTN)
                NPTT = NPT(NC)
                NPTTM1 = NPTT-1
          DO 3549 I = 1,NPTTM1
                UR  (I) = WRXP  (JTN,I)
                URT (I) = WRTXP (JTN,I)
                W  (I)  = WMJ  (JTN) * WWJT   (NC,I)
                RMAX(I) = QMJ  (JTN) * RMAXJT(NC,I)
 3549 CONTINUE
                TEMP1 = NOJ(NC,2)
                TEMP2 = NWJ(NC,2)
                SLPMAX = TEMP1*QMJ(JTN) / TEMP2 / WMJ(JTN)
                ISTT = ISTJR(JTN)
                WJ = DC1S(ISTT)*DXX(JTN)+DC2S(ISTT)*DYY(JTN)
       CALL CURVIN ( NPTT,W,RMAX,WJ,QJT,SJT,UR,URT,JTN,5,SLPMAX )
          DO 3440 I = 1,NPTTM1
                WRXP (JTN,I) = UR (I)
                WRTXP(JTN,I) = URT(I)
 3440 CONTINUE
                QJX = QJX + QJT * DC1S(ISTT)
                QJY = QJY + QJT * DC2S(ISTT)
                SJX = SJX + SJT * DC1S(ISTT)  ** 2
                SJY = SJY + SJT * DC2S(ISTT)  ** 2
                SJXY = SJT * DC1S(ISTT) * DC2S(ISTT)
          GO TO 3551
 3550 CONTINUE
                SJXY = 0.0
 3551     IF ( NSYP(JTN) .EQ. 0) GO TO 3560
                NC = NSYP(JTN)
                NPTT = NPT(NC)
                NPTTM1 = NPTT-1
          DO 3559 I = 1,NPTTM1
                UR  (I) = WRYP  (JTN,I)
                URT (I) = WRTYP (JTN,I)
                W  (I)  = WMJ  (JTN) * WWJT   (NC,I)
                RMAX(I) = QMJ  (JTN) * RMAXJT(NC,I)
 3559 CONTINUE
                TEMP1 = NOJ(NC,2)
                TEMP2 = NWJ(NC,2)
                SLPMAX = TEMP1*QMJ(JTN) / TEMP2 / WMJ(JTN)
                ISTT = ISTJR(JTN)
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                 WJ = - DC2S(ISTT)*DXX(JTN)+DC1S(ISTT)*DYY(JTN)
      CALL CURVIN ( NPTT,W,RMAX,WJ,QJT,SJT,UR,URT,JTN,6,SLPMAX )
          DO 3450 I = 1,NPTTM1
                 WRYP (JTN,I) = UR (I)
                 WRTYP(JTN,I) = URT(I)
 3450 CONTINUE
                 QJX = QJX - QJT * DC2S(ISTT)
                 QJY = QJY + QJT * DC1S(ISTT)
                 SJX = SJX + SJT * DC2S(ISTT) ** 2
                 SJY = SJY + SJT * DC1S(ISTT) ** 2
                 SJXY = SJXY - SJT * DC1S(ISTT) * DC2S(ISTT)
 3560 CONTINUE
      RETURN
      END


************************************ SUBROUTINE ************************************
      SUBROUTINE CURVIN ( NPT,W,RMAX,U,R,BK,UR,URT,JTN,JCXYZP,SLPMAX )
          IMPLICIT REAL*8 (A-H,O-Z)
COMMENT - ALL THE COMMENTS UNDER SUBROUTINE INELST APPLY HERE
      DIMENSION W(10),RMAX(10),UR(10),URT(10)
      COMMON /BLK1/  TOL,     ELEMNT,NJST,   KEEP3C,NCD3C,
     2          KEEP2,  KEEP3A,KEEP3B,KEEP4A,KEEP4B,KEEP4C,KEEP5A,
     3          KEEP5B,KEEP5C,KEEP5D,KEEP6, KEEP7,  NCD2,   NCD3A,
     4          NCD3B,  NCD4A,  NCD4B,  NCD4C,  NCD5A,  NCD5B,  NCD5C,
     5          NCD5D,  NCD6,   NCD7,   IP8,    IP9,    IP10,   ITYPE,
     6          IABAN,  IFORE,  NM,     NJT,    NST,    NLT,    M,
     7          MP1,    MP2,    ISTT,   LTT,    ITYPEL,IDJ,    NSTL
      COMMON /BLK5/ NFSUB,NITF,N1,N2
      COMMON /SKT3/ NCOUNT, NITERF
      COMMON /SKT6/       NITERM(50), INDEX
      COMMON /SKT14 / IRV(21,2,10),                       FOMOLD(50,6),
     2              IRVRSE,          ITAPE,               N3
      COMMON /SKT18/ NCHECK
      COMMON /SKT19/ JCRGON(25,6), JCUREV(25,6)
      COMMON /SKT22/ TIME, JT, IRDYN, IRSTEP(71)
COMMENT - IN THIS SUBROUTINE, IT SHOULD BE NOTED THAT THE RESISTANCE
COMMENT - AXIS HAS A NEGATIVE MULTIPLIER AS INPUT. HENCE PROPER
COMMENT - CARE IS TAKEN TO ACCOUNT FOR THIS . COMPARE & CONTRAST
COMMENT - WITH SUBROUTINE  MASING ( STRESS-STRAIN ROUTINE )
               NPTM1 = NPT - 1
               R = 0.0
               BK = 0.0
          IF ( INDEX .NE. 1 ) GO TO 1100
          DO 1000 K = 1,NPTM1
               UR(K) = URT(K)
 1000 CONTINUE
 1100 CONTINUE
          DO 2000 K = 1,NPTM1
               STIFF = RMAX(K) / W(K)
          IF ( DABS (U-UR(K)) .GE. ( W(K) - 5.0D-10) ) GO TO 1500
               BK = BK - STIFF
COMMENT - THE ABOVE MINUS SIGN IS TO FIT IN SIGN CONVENTION OF PROGRAM.
               Z = STIFF * ( U - UR(K) )
          IF ( NCHECK .NE. 1 ) GO TO 1450
          IF ( K      .NE. 1 ) GO TO 1450
          IF ( JCRGON(JTN,JCXYZP) .EQ.  0 ) GO TO 1450
               JCUREV(JTN,JCXYZP) = 1
          GO TO 1800
 1450     CONTINUE
               URT(K) = UR(K)
          IF ( INDEX .EQ. 1 ) GO TO 1800
          IF ( K .EQ. 1 ) JCRGON(JTN,JCXYZP) = 0
          GO TO 1800
 1500 CONTINUE
          IF ( U .GT. UR(K) ) GO TO 1600
               Z = - RMAX(K)
          IF ( NCHECK .NE. 1 ) GO TO 1550
          IF ( K      .NE. 1 ) GO TO 1550
          IF ( JCRGON(JTN,JCXYZP) .NE.  1 ) GO TO 1550
               JCUREV(JTN,JCXYZP) = 1
          GO TO 1800
 1550     CONTINUE
               URT(K) = U + W(K)
          IF ( INDEX .EQ. 1 ) GO TO 1800
          IF ( K .EQ. 1 ) JCRGON(JTN,JCXYZP) = -1
          GO TO 1800
 1600          Z = RMAX(K)
          IF ( NCHECK .NE. 1 ) GO TO 1650
          IF ( K      .NE. 1 ) GO TO 1650
          IF ( JCRGON(JTN,JCXYZP) .NE. -1 ) GO TO 1650
               JCUREV(JTN,JCXYZP) = 1
          GO TO 1800
 1650     CONTINUE
               URT(K) = U - W(K)
          IF ( INDEX .EQ. 1 ) GO TO 1800
          IF ( K .EQ. 1 ) JCRGON(JTN,JCXYZP) = +1
 1800     CONTINUE
               R = R + Z
 2000     CONTINUE
          IF ( ITYPE .LE. 2 ) GO TO 2050
          IF ( IRDYN .EQ. 1 .AND. NITERF .EQ. 2 ) GO TO 2100
          GO TO 2200
 2050     CONTINUE
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      IF ( NITF .EQ. 2 .AND. NITERF .EQ. 2 ) GO TO 2100
      GO TO 2200
 2100 CONTINUE
      IF ( JCUREV(JTN,JCXYZP) .EQ. 0 ) GO TO 2200
         BK = - SLPMAX
         JCUREV(JTN,JCXYZP) = 0
 2200 CONTINUE
      IF ( NCHECK .EQ. 1 ) IRVRSE = IRVRSE + JCUREV(JTN,JCXYZP)
   RETURN
   END


************************************ SUBROUTINE ************************************
      SUBROUTINE FSUB22 (RM, RO, I6, L4)
COMMENT - FSUB22 FURNISHES THE RIGHT SIDE OF SYMMETRIC STIFFNESS MATRIX
COMMENT - RM AND LOAD MATRIX RO
      IMPLICIT REAL*8 (A-H,O-Z)
      DIMENSION RM(I6,L4),RO(L6)
      DIMENSION SEMS(3,3), SEM(3,6),FEM(3),SA(3,3)
      COMMON /BLOCK2/ DXS( 25),    DYS( 25),    ZLS( 25),    DC1S( 25),
     2     DC2S( 25),   PRF( 25),    PRAE( 25),   QM( 25),     WM( 25),
     3     PRAG(25),    ELEMN(25),
     4     IOPOP( 25),  IPINL( 25),  IPINR( 25),  NC51( 25),   INLOP( 25),
     5     NAL( 25),    NSXL( 25),   NSYL( 25),   NSZL( 25),   NAR( 25),
     6     NSXR( 25),   NSYR( 25),   NSZR( 25),   NCDS( 25),   IAXOPS( 25)
      COMMON /BLOCK7/ F( 22),      AE( 22),     SX( 22),     SY( 22),
     2     SZ( 22),     QX( 22),     QY( 22),     QZ( 22),     DX( 22),
     3     DY( 22),     DZ( 22),     ERX( 22),    ERY( 22),    ERZ( 22),
     4     SQX( 22),    SQY( 22),    SQZ( 22),    U1( 22),     V1( 22),
     5     W1( 22),     U2( 22),     V2( 22),     W2( 22),     DS(3,3, 22),
     6     BM1S( 22),   BM2S( 22),   TTS( 22),    AG( 22)
      COMMON /BLOC11/ SEET(6,6)
      COMMON /BLK1/  TOL,    ELEMNT,NJST,   KEEP3C,NCD3C,
     2        KEEP2, KEEP3A,KEEP3B,KEEP4A,KEEP4B,KEEP4C,KEEP5A,
     3        KEEP5B,KEEP5C,KEEP5D,KEEP6, KEEP7, NCD2,  NCD3A,
     4        NCD3B, NCD4A, NCD4B, NCD4C, NCD5A, NCD5B, NCD5C,
     5        NCD5D, NCD6,  NCD7,  IP8,   IP9,   IP10,  ITYPE,
     6        IABAN, IFORM, NM,    NJT,   NST,   NLT,   M,
     7        MP1,   MP2,   ISTT,  LTT,   ITYPEL,IDJ,   NSTL
      COMMON /BLK2/ XL,XR,X1,X2,          H,TH,HSQ,HCU,X2L,I1,I2,NQ
      COMMON /BLK5/ NFSUB,NITF,N1,N2
      COMMON / RI / NL, ML, J1
         IAXOPT = IAXOPS(ISTT)
COMMENT - I IS STATION NUM -- IP1 IS ELEMENT NUM -- J1 IS EQUATION NUM
      DO 6000 I=1,MP1
         J1 = 3*I - 2
      IF (ML .EQ. -1) GO TO 2800
      IF (I .NE. 1) GO TO 2100
      DO 1600  JJ = 1, 3
      DO 1600  KK = 1, 3
         SEMS(JJ,KK) = 0.0
 1600 CONTINUE
 2100 CONTINUE
      IF (I .LT. MP1) GO TO 2400
      DO 2300  JJ = 1,6
      DO 2300  KK = 1,6
 2300    SEET(JJ,KK) = 0.0
      GO TO 2500
 2400    IP1 = I + 1
COMMENT - CALL ELEMST TO OBTAIN 6 X 6 ELEMENT STIFFNESS MATRIX
     CALL      ELEMST ( IP1,NITF )
 2500 CONTINUE
COMMENT - FORM THREE ROWS OF MEMBER STIFFNESS MATRIX SEM
      DO 2600  JJ = 1, 3
      DO 2600  KK = 1, 3
         SEM(JJ,KK) = SEET(JJ,KK) + SEMS(JJ,KK)
         SEM(JJ,KK + 3) = SEET(JJ,KK + 3)
         SEMS(JJ,KK) = SEET(JJ+ 3, KK + 3)
 2600 CONTINUE
COMMENT - ADD IN SPRING STIFFNESSES
         SEM(3,3) = SEM(3,3) + SZ(I)
      IF (I .EQ. 1 .OR. I .EQ. MP1) GO TO 2650
      IF ( IAXOPT .EQ. 2) GO TO 2700
 2650    SEM(1,1) = SEM(1,1) + SX(I)
         SEM(2,2) = SEM(2,2) + SY(I)
      GO TO 2800
COMMENT - MEMBER SPRINGS IN STRUCTURE DIRECTIONS
 2700    SXT = SX(I)
         SYT = SY(I)
     CALL      SANGLE (SA,SXT,SYT)
         SEM(1,1) = SEM(1,1) + SA(1,1)
         SEM(1,2) = SEM(1,2) + SA(1,2)
         SEM(2,1) = SEM(2,1) + SA(2,1)
         SEM(2,2) = SEM(2,2) + SA(2,2)
 2800    FEM(1) = ERX(I)
         FEM(2) = ERY(I)
         FEM(3) = ERZ(I)
      DO 3600  K = 1,5
 3600    SEM(2,K) = SEM(2, K + 1)
      DO 3700  K = 1,4
 3700    SEM(3,K) = SEM(3,K + 2)
         SEM(2,6) = 0.0
         SEM(3,6) = 0.0
         SEM(3,5) = 0.0
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          J1P1 = J1 + 1
          J1P2 = J1 + 2
      IF (ML .EQ. -1) GO TO 5200
      DO 5100 J2=1,6
          RM(J1,J2)   = SEM(1,J2)
          RM(J1P1,J2) = SEM(2,J2)
          RM(J1P2,J2) = SEM(3,J2)
5100     CONTINUE
5200      RO(J1)   = FEM(1)
          RO(J1P1) = FEM(2)
          RO(J1P2) = FEM(3)
6000     CONTINUE
      RETURN
      END


***************************************** SUBROUTINE *****************************************
      SUBROUTINE ELEMST ( I,NITF )
COMMENT - SUBROUTINE ELEMST FORMS THE ELEMENT 6 X 6 STIFFNESS MATRIX
COMMENT - IT ALSO STORES IN SUBSCRIPTED ARRAY THE ELEMENT-END-FORCES
COMMENT - FOR ALL ELEMENTS FOR LATER USE IN FORMLD. ( CNLY ON FIRST
COMMENT - ITERATION  NITF = 1 )
COMMENT - IN ADDITION IT STORES IN ONE 6,6 MATRIX, THE UPPER HALF OF
COMMENT - THE STIFFNESS MATRIX OF THE FIRST ELEMENT, AND THE LOWER
COMMENT - HALF OF THE STIFFNESS MATRIX OF THE LAST ELEMENT FOR
COMMENT - LATER USE IN  MEMENI
      IMPLICIT REAL*8 (A-H,O-Z)
      DIMENSION B(6,6), BT(6,6), D(6,6), TM(6,6)
      DIMENSION BMS(22), SHS(22)
      COMMON /BLOCK7/ P( 22),        AE( 22),     SX( 22),     SY( 22),
     2    SZ( 22),     QX( 22),      QY( 22),     QZ( 22),     DX( 22),
     3    DY( 22),     DZ( 22),      ERX( 22),    ERY( 22),    ERZ( 22),
     4    SQX( 22),    SQY( 22),     SQZ( 22),    U1( 22),     V1( 22),
     5    W1( 22),     U2( 22),      V2( 22),     W2( 22),     DS(3,3, 22),
     6    BM1S( 22),   BM2S( 22),    TTS( 22),    AG( 22)
      COMMON /BLOC11/ SEET(6,6)
      CCMMON /BLK1/  TCL,    ELEMNT,NJST,  KEEP3C,NCD3C,
     2       KEEP2, KEEP3A,KEEP3B,KEEP4A,KEEP4B,KEEP4C,KEEP5A,
     3       KEEP5B,KEEP5C,KEEP5D,KEEP6, KEEP7, NCD2,  NCD3A,
     4       NCD3B, NCD4A, NCD4B, NCD4C, NCD5A, NCD5B, NCD5C,
     5       NCD5D, NCD6,  NCD7,  IP8,   IP9,   IP10,  ITYPE,
     6       IABAN, IFORM, NM,    NJT,   NST,   NLT,   M,
     7       MP1,   MP2,   ISTT,  LTT,   ITYPEL,IDJ,   NSTL
      COMMON /BLK2/ XL,XR,X1,X2,         H,TH,HSQ,HCU,X2L,I1,I2,NQ
      CCMMON /BLK7/ INLOPT,IFAE,KCFPJ,KOFFOW,KOFFSE
      COMMON /SKT7/      U1TT(21),      V1TT(21),      W1TT(21),
     2                   U2TT(21),      V2TT(21),      W2TT(21)
      COMMON /SKT8/      SEEE(6,6)
      COMMON /SKT14 / IRV(21,2,10),                    FCMOLD(50,6),
     2               IRVESE,        ITAPE,             N3
      COMMON /SKT23/ PDELTA
      CCMMON /SKT35/ TMESTP
      EQUIVALENCE (BMS(1),BM1S(1)) , (SHS(1),BM2S(1))
          DATA PDNO /4HPDNO/, PDN /4H PDN/
          DATA ANEW /4HANEW/, ANCNE /5HANONE/
          DATA SHEAR /5HSHEAR/
      IF ( ITYPE .LE. 2 ) TMESTP = ANCNE
COMMENT - LOCAL = 1      P-DELTA EFFECTS ARE      CONSIDERED
COMMENT - LOCAL = 0      P-DELTA EFFECTS ARE NOT CONSIDERED
          LOCAL  = 1
      IF (PDELTA.EQ.PDNO .OR. PDELTA.EQ.PDN) LOCAL  = 0
          IM1 = I - 1
      IF (ELEMNT .EQ. SHEAR) GO TO 2000
COMMENT - COMPUTE ELEMENT DEFCRMATIONS
          DDX = DX(I) - DX(IM1)
          DDY = DY(I) - DY(IM1)
          DZ1 = DZ(IM1)
          DZ2 = DZ(I)
      IF ( LOCAL  .NE. 0 ) GC TO 300
COMMENT - COMPUTE DEFORMATIONS BASED ON SMALL DISPLACEMENTS
          S       = DDY - 0.5 * H * ( DZ1+DZ2 )
          DELTA   = DDX
          THETA   = S / H
          TAU1    = THETA   - DZ1
          TAU2    = DZ2     - THETA
COMMENT - FORM THE TRANSPCSE OF THE ELEMENT DEFORMATION-DISPLACEMENT
COMMENT - MATRIX. ( BASED ON SMALL DISPLACEMENT THEORY )
      DO 100 J = 1,6
      DO 100 K = 1,3
100       BT(J,K) =  0.0
          BT(1,1) = -1.0
          BT(4,1) =  1.0
          BT(2,2) = -1.0 / H
          BT(3,2) = -1.5
          BT(5,2) =  1.0 / H
          BT(6,2) = -0.5
          BT(2,3) =  1.0 / H
          BT(3,3) =  0.5
          BT(5,3) = -1.0 / H
          BT(6,3) =  1.5
      GO TO 400
300   CONTINUE
          COSIM1 =DCOS(DZ1)
          COSI   =DCOS(DZ2)
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                  SINIM1 =DSIN(DZ1)
                  SINI   =DSIN(DZ2)
                  COSCOS = COSI + COSIM1
                  SINSIN = SINI + SINIM1
                  R = DDX + H*(1.0 - 0.5*COSCOS)
                  S = DDY - 0.5*H*SINSIN
                  HPR = H + R
                  HPD = DSQRT(HPR*HPR + S*S)
                  DELTA    = HPD - H
                  THETA =DATAN(S/HPR)
                  TAU1 = THETA - DZ1
                  TAU2 = DZ2 - THETA
COMMENT - COMPUTE FOR CONVENIENCE
                  HPRS1 = HPR*SINIM1
                  HPRS2 = HPR*SINI
                  HPRC1 = HPR*COSIM1
                  HPRC2 = HPR*COSI
                  SC1    = S*COSIM1
                  SC2    = S*COSI
                  SS1    = S*SINIM1
                  SS2    = S*SINI
                  HPDE1I = 1.0/HPD
                  HPDE2I = HPDE1I*HPDE1I
                  HO2 = 0.5*H
COMMENT - FORM THE TRANSPOSE OF THE ELEMENT DEFORMATION-DISPLACEMENT
COMMENT - MATRIX
                  BT(1,1)   = -HPR*HPDE1I
                  BT(2,1)   = -S*HPDE1I
                  BT(3,1)   = HO2*HPDE1I*(HPRS1 - SC1)
                  BT(4,1)  = - BT(1,1)
                  BT(5,1)  = - BT(2,1)
                  BT(6,1)   = HO2*HPDE1I*(HPRS2 - SC2)
                  BT(1,2)   = S*HPDE2I
                  BT(2,2)   = -HPR*HPDE2I
                  BT(3,2)   = -1.0 -HO2*HPDE2I*(HPRC1 + SS1)
                  BT(4,2)  = -BT(1,2)
                  BT(5,2)  = -BT(2,2)
                  BT(6,2)   = -HO2*HPDE2I*(HPRC2 + SS2)
                  BT(1,3)  = BT(4,2)
                  BT(2,3)  = BT(5,2)
                  BT(3,3)   = HO2*HPDE2I*(HPRC1 + SS1)
                  BT(4,3)  = BT(1,2)
                  BT(5,3)  = BT(2,2)
                  BT(6,3)   = 1.0 - BT(6,2)
  400      CONTINUE
           IF (IPAE .EQ. 1) GO TO 700
           DO 500   J = 1,3
           DO 500   K = 1,3
  500             D(J,K) = DS(J,K,I)
                  TT = TTS(I)
                  BM1 = BM1S(I)
                  BM2 = BM2S(I)
           GO TO 800
COMMENT - CALL FAEREV TO FIND INTERNAL FORCES IN ELEMENT TT,BM1,BM2 AND
COMMENT - ELEMENT FORCE-DEFORMATION MATRIX D
  700 CALL        FAEREV (DELTA, TAU1, TAU2, I, D, TT, BM1, BM2 )
           IF ( TMESTP .EQ. ANEW ) GO TO 710
           IF ( ITYPE .EQ. 3 .OR. ITYPE .EQ. 4 ) GO TO 800
           IF ( IRVRSE .NE. 0 ) GO TO 710
           IF ( NITF .GT. 1 ) GO TO 800
  710      CONTINUE
           IF ( LOCAL  .NE. 0 ) GO TO 750
                  V1TT(I) = ( BM2 - BM1 ) / H
                  U2TT(I) = TT
                  V2TT(I) = -V1TT(I)
                  U1TT(I) = -U2TT(I)
                  W1TT(I) = -BM1 + 0.5 * V1TT(I) * H
                  W2TT(I) =  BM2 + 0.5 * V1TT(I) * H
           GO TO 800
  750      CONTINUE
                  SINT = S / ( H + DELTA )
                  COST = ( H + R ) / ( H + DELTA )
                  VT   = ( BM2 - BM1 ) / ( H + DELTA )
COMMENT - STORE FOR USE BY  FORMLD
                  U2TT  (I) = TT * COST + VT * SINT
                  V2TT  (I) = TT * SINT - VT * COST
                  U1TT  (I) = - U2TT (I)
                  V1TT  (I) = - V2TT (I)
                  W1TT  (I) = - BM1+0.5*( -U1TT(I)*SINIM1+V1TT(I)*COSIM1 )*H
                  W2TT  (I) =   BM2+0.5*( -U1TT(I)*SINI   +V1TT(I)*COSI   )*H
  800      CONTINUE
COMMENT - FORM FIRST PART OF TRIPLE PRODUCT
        CALL      MATMPY (BT,6,3,D,3,TM)
COMMENT - FORM THE ELEMENT DEFORMATION-DISPLACEMENT MATRIX
           DO 850 K = 1,3
           DO 850   J = 1,6
  850             B(K,J) = BT(J,K)
COMMENT - COMPLETE THE TRIPLE PRODUCT
        CALL      MATMPY (TM,6,3,B,6,SEET)
COMMENT - INITIAL STRESS MATRIX IS NULL IF P-DELTA EFFECTS IGNORED
           IF ( LOCAL  .EQ. 0 ) GO TO 9999
COMMENT - COMPUTE FOR CONVENIENCE
                  HPDE3I = HPDE2I*HPDE1I
                  SE2      = S*S
                  HPRE2    = HPR*HPR
                  TTM      = TT*HPDE3I
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                    TTMHC2    = TTM*HO2
                    HPDE2     = HPD*HPD
COMMENT - COMPUTE THE PORTION OF THE INITIAL STRESS MATRIX DUE TC THRUST
                    TM(1,1)   =  TTM*SE2
                    TM(1,2)   = -TTM*S*HPR
                    TM(1,3)   = -TTMHO2 *S*(SS1 + HPRC1)
                    TM(1,4)   = -TM(1,1)
                    TM(1,5)   = -TM(1,2)
                    TM(1,6)   = -TTMHO2 *S*(SS2 + HPRC2)
                    TM(2,2)   =  TTM*HPRE2
                    TM(2,3)   =  TTM*HO2*HPR*(SS1 + HPRC1)
                    TM(2,4)   =  TM(1,5)
                    TM(2,5)   = -TM(2,2)
                    TM(2,6)   =  TTMHO2 *HPR*(SS2 + HPRC2)
                    TM(3,3)   =  TTMHO2 *(HO2*(SS1 + HPRC1)**2    +
     2                          HPDE2*(SS1 + HPRC1))
                    TM(3,4)   = -TM(1,3)
                    TM(3,5)   = -TM(2,3)
                    TM(3,6)   =  TTMHO2 * HO2*(SS1 + HPRC1)*(SS2 + HPRC2)
                    TM(4,4)   =  TM(1,1)
                    TM(4,5)   =  TM(1,2)
                    TM(4,6)   = -TM(1,6)
                    TM(5,5)   =  TM(2,2)
                    TM(5,6)   = -TM(2,6)
                    TM(6,6)   =  TTMHO2 *(HO2*(SS2 + HPRC2)**2    +
     2                          HPDE2*(SS2 + HPRC2))
                 N1 = 0
COMMENT - ADD ON TO ELEMENT STIFFNESS MATRIX
              DO 998  K = 1,6
                 N1  = N1 + 1
              DO 998 J = N1, 6
                 SEET(K,J) = SEET(K,J) + TM(K,J)
  998         CONTINUE
                 VT = (BM2 - BM1)/HPD
                 VTM        = VT*HPDE3I
                 VTMHO2     = VTM*HO2
                 HPRS       = HPRE2 - SE2
COMMENT - COMPUTE THE PORTION OF THE INITIAL STRESS MATRIX DUE TO SHEAR
                 TM(1,1)   = -VTM*HPR*S*2.0
                 TM(1,2)   =  VTM*HPRS
                 TM(1,3)   =  VTMHO2*(HPRS*COSIM1 + S*HPR*SINIM1*2.0)
                 TM(1,4)   = -TM(1,1)
                 TM(1,5)   = -TM(1,2)
                 TM(1,6)   =  VTMHO2*(HPRS*COSI    + S*HPR*SINI   *2.0)
                 TM(2,2) = -TM(1,1)
                 TM(2,3)   =  VTMHO2*(-HPRS*SINIM1 + S*HPR*COSIM1*2.0)
                 TM(2,4)   =  TM(1,5)
                 TM(2,5)   = -TM(2,2)
                 TM(2,6)   =  VTMHO2*(-HPRS*SINI    + S*HPR*CCSI   *2.0)
                 TM(3,3)   = -VTMHO2*(HPDE2*(HPR*SINIM1 - S*COSIM1)  +
     2        H*HPRS*SINIM1*COSIM1 + H   *HPR*S*(SINIM1**2   - COSIM1**2  ))
                 TM(3,4)   = -TM(1,3)
                 TM(3,5)   = -TM(2,3)
                 TM(3,6)   = -VTMHO2*HO2*(HPRS*(SINIM1*COSI + COSIM1*SINI)
     2   +   S*HPR*(SINIM1*SINI - COSIM1*COSI)*2.0)
                 TM(4,4)   =  TM(1,1)
                 TM(4,5)   =  TM(1,2)
                 TM(4,6)   = -TM(1,6)
                 TM(5,5)   =  TM(2,2)
                 TM(5,6)   = -TM(2,6)
                 TM(6,6)   = -VTMHO2*(HPDE2*(HPR*SINI    - S*COSI   )  +
     2        H*HPRS*SINI   *COSI    + H   *HPR*S*(SINI   **2   - COSI   **2  ))
                 N1 = 0
COMMENT - ADD ON TO ELEMENT STIFFNESS MATRIX
              DO 999  K = 1,6
                 N1  = N1 + 1
              DO 999 J = N1, 6
                 SEET(K,J) = SEET(K,J)  + TM(K,J)
                 SEET(J,K) = SEET(K,J)
  999         CONTINUE
              GO TO 9999
 2000         CONTINUE
COMMENT - COMPUTE ELEMENT DEFORMATIONS
                 DDX = DX(I) - DX(IM1)
                 DDY = DY(I) - DY(IM1)
                 DDZ = DZ(I) - DZ(IM1)
              IF (LOCAL .NE. 0) GO TO 2300
COMMENT - COMPUTE DEFORMATICNS BASED ON SMALL DISPLACEMENTS
                 THETA   = DDY/TH
                 DELA    = DDX
                 PSI1    = DZ(IM1) - THETA
                 PSI2    = DZ(I)   - THETA
                 DELS    = H*(PSI1 + PSI2)
                 DELM    = DDZ
COMMENT - FORM THE ELEMENT DEFORMATION - DISPLACEMENT MATRIX BASED
COMMENT - ON SMALL DISPLACEMENT THEORY
              DO 2100 J = 1,6
              DO 2100 K = 1,3
 2100            B(K,J)  =   0.0
                 B(1,1)  =  -1.0
                 B(1,4)  =   1.0
                 B(2,3)  =  -1.0
                 B(2,6)  =   1.0
                 B(3,2)  =   1.0
                 B(3,3)  =   H
                 B(3,5)  =  -1.0
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                  B(3,6) = H
           GO TO 2400
  2300     CONTINUE
COMMENT - COMPUTE FOR CONVENIENCE
                  THDX = TH + DDX
                  THDXI = 1.0/THDX
                  THETA = DATAN(DDY*THDXI)
                  PSI1 = DZ(IM1) - THETA
                  PSI2 = DZ(I) - THETA
                  COS1 = DCOS(PSI1)
                  COS2 = DCOS(PSI2)
                  SIN1 = DSIN(PSI1)
                  SIN2 = DSIN(PSI2)
                  COSCOS = COS1 + COS2
                  SINSIN = SIN1 + SIN2
                  SINT = DSIN(THETA)
                  COST = DCOS(THETA)
                  SIN2T = 2.0*SINT*COST
                  COST2 = COST*COST
                  DELA = THDX/COST - H*COSCOS
                  DELS = H*SINSIN
                  DELM = DDZ
COMMENT - FORM ELEMENT DEFORMATION DISPLACEMENT MATRIX
                  B(1,1) = -COST - DELS*SIN2T*THDXI/2.0
                  B(1,2) = -SINT +DELS*COST2*THDXI
                  B(1,3) = H*SIN1
                  B(1,4) = -B(1,1)
                  B(1,5) = -B(1,2)
                  B(1,6) = H*SIN2
                  B(2,1) = 0.0
                  B(2,2) = 0.0
                  B(2,3) = -1.0
                  B(2,4) = 0.0
                  B(2,5) = 0.0
                  B(2,6) = -B(2,3)
                  B(3,1) = -H*SIN2T*COSCOS*THDXI/2.0
                  B(3,2) = H*COST2*COSCOS*THDXI
                  B(3,3) = H*COS1
                  B(3,4) = -B(3,1)
                  B(3,5) = -B(3,2)
                  B(3,6) = H*COS2
  2400     CONTINUE
           IF (IFAE .EQ. 1) GO TO 2700
           DO 2500 J=1,3
           DO 2500 K=1,3
  2500            D(J,K) = DS(J,K,I)
                  TT = TTS(I)
                  BM = BMS(I)
                  SH = SHS(I)
           GO TO 2800
COMMENT - CALL DETAMS TO FIND INTERNAL FORCES TT,BM,SH AND ELEMENT
COMMENT - FORCE DEFORMATION MATRIX D IN SHEAR TYPE ELEMENT
  2700 CALL       DETAMS (DELA,DELM,DELS,I,D,TT,BM,SH)
           IF (TMESTP .EQ. ANEW) GO TO 2710
           IF (ITYPE .EQ. 3 .OR. ITYPE .EQ. 4) GO TO 2800
           IF (INVRSE .NE. 0) GO TO 2710
           IF (NITF .GT. 1) GO TO 2800
  2710     CONTINUE
           IF (LOCAL .NE. 0) GO TO 2750
                  U1TT(I) = -TT
                  V1TT(I) = SH
                  W1TT(I) = -BM + H*SH
                  U2TT(I) = TT
                  V2TT(I) = -SH
                  W2TT(I) = BM + H*SH
           GO TO 2800
  2750     CONTINUE
                  DELAD2 = DELA/2.0
                  DELSD2 = DELS/2.0
COMMENT - STORE FOR USE BY FORMLD
                  U1TT(I) = -TT*COST - SH*SINT
                  V1TT(I) = -TT*SINT + SH*COST
                  W1TT(I) = -BM + SH*(H*COS1 + DELAD2) +
     2            TT*(H*SIN1 - DELSD2)
                  U2TT(I) = -U1TT(I)
                  V2TT(I) = -V1TT(I)
                  W2TT(I) = BM + SH*(H*COS2 + DELAD2) +
     2            TT*(H*SIN2 -DELSD2)
  2800     CONTINUE
COMMENT - FORM FIRST PART OF TRIPLE PRODUCT
           DO 2850 K = 1,3
           DO 2850 J = 1,6
  2850            BT(J,K) = B(K,J)
           CALL   MATMPY (BT,6,3,D,3,TM)
COMMENT - COMPLETE THE TRIPLE PRODUCT
           CALL   MATMPY (TM,6,3,B,6,SEET)
COMMENT - INITIAL STRESS MATRIX IS NULL IF P-DELTA EFFECTS ARE IGNORED
           IF (LOCAL .EQ. 0) GO TO 9999
COMMENT - COMPUTE FOR CONVENIENCE
                  COS2T = 2.0*COST2 - 1.0
                  THDXI2 = THDXI*THDXI
                  COST3 = COST*COST2
                  COST4 = COST2*COST2
                  SIN2T2 = SIN2T*SIN2T
                  HT = H*TT
                  HTI = HT*THDXI
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COMMENT - COMPUTE THE PORTION OF THE STIFFNESS MATRIX IN THE SHEAR
COMMENT - MODEL DUE TO INITIAL THRUST
               TM(1,1) = TT*(SINT*SIN2T*THDXI/2.0 + THDXI2*(-DELS*
     2         SIN2T*COST2 + H*SIN2T2*COSCOS/4.0))
               TM(1,2) = TT*COST2*(-SINT*THDXI + THDXI2*(DELS*COS2T
     2         -H*SIN2T*COSCOS/2.0))
               TM(1,3) = -HTI*SIN2T*COS1/2.0
               TM(1,4) = -TM(1,1)
               TM(1,5) = -TM(1,2)
               TM(1,6) = -HTI*SIN2T*COS2/2.0
               TM(2,2) = TT*(COST3*THDXI + THDXI2*(DELS*SIN2T*COST2 +
     2         H*COST4*COSCOS))
               TM(2,3) = HTI*COST2*COS1
               TM(2,4) = -TM(1,2)
               TM(2,5) = -TM(2,2)
               TM(2,6) = HTI*COST2*COS2
               TM(3,3) = HT*COS1
               TM(3,4) = -TM(1,3)
               TM(3,5) = -TM(2,3)
               TM(3,6) = 0.0
               TM(4,4) = TM(1,1)
               TM(4,5) = TM(1,2)
               TM(4,6) = -TM(1,6)
               TM(5,5) = TM(2,2)
               TM(5,6) = -TM(2,6)
               TM(6,6) = HT*COS2
               N1 = 0
COMMENT - ADD ON TO ELEMENT STIFFNESS MATRIX
          DO 2998 K = 1,6
               N1 = N1 +1
          DO 2998 J =N1,6
               SEET(K,J) = SEET(K,J) + TM(K,J)
 2998     CONTINUE
COMMENT - COMPUTE THE PORTION OF THE STIFFNESS MATRIX IN THE SHEAR
COMMENT - MODEL DUE TO INITIAL SHEAR
               HS = H*SH
               HSI = HS*THDXI
               TM(1,1) = -SH*THDXI2*(H*SIN2T*COST2*COSCOS +
     2         DELS*SIN2T2/4.0)
               TM(1,2) = SH*THDXI2*COST2*(H*COS2T*COSCOS +
     2         DELS*SIN2T/2.0)
               TM(1,3) = HSI*SIN2T*SIN1/2.0
               TM(1,4) = -TM(1,1)
               TM(1,5) = -TM(1,2)
               TM(1,6) = HSI*SIN2T*SIN2/2.0
               TM(2,2) = SH*THDXI2*(-DELS*COST4 + H*COST2*
     2         SIN2T*COSCOS)
               TM(2,3) = -HSI*COST2*SIN1
               TM(2,4) = -TM(1,2)
               TM(2,5) = -TM(2,2)
               TM(2,6) = -HSI*COST2*SIN2
               TM(3,3) = -HS*SIN1
               TM(3,4) = -TM(1,3)
               TM(3,5) = -TM(2,3)
               TM(3,6) = 0.0
               TM(4,4) = TM(1,1)
               TM(4,5) = TM(1,2)
               TM(4,6) = -TM(1,6)
               TM(5,5) = TM(2,2)
               TM(5,6) = -TM(2,6)
               TM(6,6) = -HS*SIN2
               N1=0
COMMENT - ADD ON TO ELEMENT STIFFNESS MATRIX
          DO 2999 K = 1,6
               N1=N1+1
          DO 2999 J = N1,6
               SEET(K,J) = SEET(K,J) + TM(K,J)
               SEET(J,K) = SEET(K,J)
 2999     CONTINUE
 9999     CONTINUE
          IF ( ITYPE .GE. 3 ) GO TO 1000
          IF ( IFAE .EQ. 0 ) GO TO 1400
 1000     CONTINUE
COMMENT - STORE THE FOLLOWING FOR END ELEMENTS ONLY FOR LATER USE
COMMENT - IN  MEMENI
          IF ( I .NE. 2 ) GO TO 1200
          DO 1100 K = 1,3
          DO 1100 J = 1,6
               SEEE (K,J) = SEET (K,J)
 1100 CONTINUE
 1200     IF ( I .NE. MP1 ) GO TO 1400
          DO 1300 K = 4,6
          DO 1300 J = 1,6
               SEEE (K,J) = SEET (K,J)
 1300 CONTINUE
 1400 CONTINUE
      RETURN
      END
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 ********************************** SUBROUTINE ***********************************
      SUBROUTINE FAEREV (DELTA, TAU1, TAU2, I, D, TT, BM1, BM2 )
COMMENT - SUBROUTINE FAEREV COMPUTES THE AVERAGE AXIAL THRUST AND THE
C         BENDING MOMENTS AT THE TWO DISCRETE HINGES IN AN ELEMENT, AND
C         ALSO THE INCREMENTAL FORCE-DEFORMATION MATRIX FOR AN ELEMENT
C         FOR LINEAR STRESS-STRAIN CURVES (INLOPT = 0) THE EQUATIONS OF
C         FRAME 21 ARE USED FOR NONLINEAR STRESS-STRAIN CURVES
C         (INLOPT = 1) A NUMERICAL INTEGRATION IS DONE
COMMENT - WITH SOME LIMITATIONS ON THE SIG-EP CURVE INPUT, CAPABILITY
C         IS BUILT IN TO THIS SUBROUTINE TO DO AN INELASTIC ANALYSIS
C         THE CHOICE IS TO BE EXERCISED BY THE USER
      IMPLICIT REAL*8 (A-H,O-Z)
      DIMENSION D(6,6)
      DIMENSION TTMP(2), BMTMP(2), AETMP(2), AEYTMP(2), EITMP(2),
     2          TTEM(2), BMTEM(2), AETEM(2), AEYTEM(2), EITEM(2)
      DIMENSION EPSCOM(10), SIGCOM(10)
      DIMENSION SIGHIS(2), STFHIS(2)
      COMMON /BLOCK2/ DXS( 25),     DYS( 25),     ZLS( 25),     DC1S( 25),
     2     DC2S( 25),    PRF( 25),     PRAE( 25),    QM( 25),      WM( 25),
     3     PRAG(25),     ELEMN(25),
     4     IOPOP( 25),   IPINL( 25),   IPINR( 25),   NC51( 25),    INLOP( 25),
     5     NAL( 25),     NSXL( 25),    NSYL( 25),    NSZL( 25),    NAR( 25),
     6     NSXR( 25),    NSYR( 25),    NSZR( 25),    NCDS( 25),    IAXOPS( 25)
      COMMON /BLOCK4/ FCMM(50,6),SMC(50,21),IST(50),     LT(50),
     2     JT1(50),      JT2(50),      NITE(50),     IMM(50),      IMC(50)
      COMMON /BLOCK7/ F( 22),       AE( 22),      SX( 22),      SY( 22),
     2     SZ( 22),      QX( 22),      QY( 22),      QZ( 22),      DX( 22),
     3     DY( 22),      DZ( 22),      ERX( 22),     ERY( 22),     ERZ( 22),
     4     SQX( 22),     SQY( 22),     SQZ( 22),     U1( 22),      V1( 22),
     5     W1( 22),      U2( 22),      V2( 22),      W2( 22),      DS(3,3, 22),
     6     BM1S( 22),    BM2S( 22),    TTS( 22),     AG( 22)
      COMMON /BLOCK9/ BCL(10),      DBCL(10),     DCL(10),      DDCL(10),
     2     YCL(10),      DYCL(10),     SIGL(10,11),  EPSL(10,11),DSIGL(10,11),
     3     DEPSL(10,11),ISST(10),      NSSL(10),     NSSR(10)
      COMMON /BLOC12/ SM(20,10),    EM(20,10),    BI(20,10),    DI(20,10),
     2     YI(20,10),    NSS(20,10),   NA(20),       NCDA(20),     IRECT(20,10)
      COMMON /BLOC13/ NPTS( 08),     ISS( 08),    NSIG(08,11),NEPS(08,11),
     2     NSIT(11),     NEPT(11)
      COMMON /BLOC15/ EPST(21),     SIGT(21),     EPSTS(11),    SIGTS(11)
      COMMON /BLK1/   TOL,     ELEMNT,NJST,   KEEP3C,NCD3C,
     2               KEEP2, KEEP3A,KEEP3E,KEEP4A,KEEP4B,KEEP4C,KEEP5A,
     3               KEEP5B,KEEP5C,KEEP5D,KEEP6, KEEP7, NCD2,  NCD3A,
     4               NCD3B, NCD4A, NCD4B, NCD4C, NCD5A, NCD5B, NCD5C,
     5               NCD5D, NCD6,  NCD7,  IP8,   IP9,   IP10,  ITYPE,
     6               IABAN, IFORM, NM,    NJT,   NST,   NLT,   M,
     7               MP1,   MP2,   ISIT,  LTT,   ITYPEL,IDJ,   NSTL
      COMMON /BLK2/ XL,XR,X1,X2,              H,TH,HSQ,HCU,X2L,I1,I2,NQ
      COMMON /BLK7/ INLOPT.IFAE.KOFFJ.KOFFOW.KOFFSE
      COMMON/ITC/ ERR1,ERR2,ER1,ER2,DTI,CM,NTI,MM(20),MJ(20),MNITF,
     2            MNITM,NSMJ,NSMM
      COMMON /SKT10/       NDIV(20,10),    NPCTOT(20)
      COMMON /SKT12/       EPSIEL(08,03), SIGMAX(08,03)
      COMMON /SKT15/ JJ
      COMMON /SKT25/ TTSLEF, TTSRGT, NLE, NRE
      COMMON /SKT31/ ALPHA (8), BETA  (8), SMLSLP(8), EPSTHD(8),
     2               SLOPHD (8), SIGULT(8), MATRL  (8)
      IF (I .GT. 2) GO TO 1500
COMMENT - SKIP FOR ALL BUT FIRST ELEMENT
COMMENT - COMPUTE NUMBER OF RIGID ELEMENTS AND NUMBER OF LINEAR ELEMENTS
COMMENT - AT ENDS OF MEMBERS
               NR = - IPINL(ISTT)/10
               NE = - IPINL(ISTT) - 10*NR
               NLR = 1 + NR
               NLE = NLR + NE
               NR = - IPINR(ISTT)/10
               NE = - IPINR(ISTT) - 10*NR
               NRR = MP2 - NR
               NRE = NRR - NE
 1500     CONTINUE
          IF (INLOPT .EQ. 1) GO TO 2100
COMMENT - COMPUTE THRUST AND BENDING MOMENTS AND INCREMENTAL FORCE
COMMENT - DEFORMATION MATRIX FOR ELEMENT WITH LINEAR STRESS-STRAIN CURVE
               D(1,1) = AE(I)/TH
               D(2,2) = F(I)/H
               D(3,3) = D(2,2)
               D(1,2) = 0.0
               D(1,3) = 0.0
               D(2,1) = 0.0
               D(2,3) = 0.0
               D(3,1) = 0.0
               D(3,2) = 0.0
               BM1  = F(I)*TAU1/H
               BM2  = F(I)*TAU2/H
               TT   = AE(I)*DELTA/TH
          IF (I .GT. NLR .AND. I .LT. NRR) GO TO 4100
COMMENT - MULTIPLY VALUES BY 10 FOR RIGID ELEMENT
               BM1 = BM1*10.0
               BM2 = BM2*10.0
               TT = TT*10.0
               D(1,1) = D(1,1)*10.0
               D(2,2) = D(2,2)*10.0
               D(3,3) = D(3,3)*10.0
          GO TO 4100
 2100     CONTINUE
          IF (I .GT. 2) GO TO 2500
COMMENT - SKIP FOR ALL BUT FIRST ELEMENT
```

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COMMENT - COMPUTE SECTION PROPERTIES AT MEMBERS
COMMENT - FROM JOINT AND DIFFERENCE IN THESE PROPERTIES BETWEEN FROM AND
COMMENT - TO JOINTS
            NALT = NAL(ISTT)
            NART = NAR(ISTT)
            NCDAT = NCLA(NALT)
      DO 2200  J = 1,NCDAT
            BCL(J) = BI(NALT,J)
            DBCL(J) = (BI(NART,J) - BCL(J))/M
            DCL(J) = DI(NALT,J)
            DDCL(J) = (DI(NART,J) - DCL(J))/M
            YCL(J) = YI(NALT,J)
            DYCL(J) = (YI(NART,J) - YCL(J))/M
            NSSL(J) = NSS(NALT,J)
            NSSLT = NSSL(J)
COMMENT - IF SIG-EP CURVE IS NON-LINEAR BUT ELASTIC, THEN COMPUTE
COMMENT - STRESS-STRAIN CURVE AT MEMBERS FROM JOINT AND DIFFERENCE
COMMENT - IN THESE PROPERTIES BETWEEN FROM AND TO JOINTS
COMMENT - IF SIG-EP CURVE IS NON-LINEAR AND INELASTIC, THEN THESE
COMMENT - STEPS NEED NOT BE DONE SINCE THE CURVES INCLUDING THE
COMMENT - TWO MULTIPLIERS MUST BE SAME AT THE FROM AND TO JOINTS
      IF ( NDIV(NALT,J) .NE. 0 ) GO TO 2200
            NSSR(J) = NSS(NART,J)
            NSSRT = NSSR(J)
            NPTST = NPTS(NSSLT)
            ISST(J) = ISS(NSSLT)
      DO 2180 K = 1,NPTST
            SIGL(J,K) = NSIG(NSSLT,K)*SM (NALT,J)
            SIGR = NSIG(NSSRT,K)*SM(NART,J)
            EPSL(J,K) = NEPS(NSSLT,K)*EM(NALT,J)
            EPSR = NEPS(NSSRT,K)*EM(NART,J)
            DSIGL(J,K) = (SIGL(J,K) - SIGR)/M
            DEPSL(J,K) = (EPSL(J,K) - EPSR)/M
 2180 CONTINUE
 2200 CONTINUE
 2500 CONTINUE
COMMENT - (IR = 1) FOR RIGID ELEMENT
COMMENT - (IE = 1) FOR LINEAR ELEMENT
            IR = 0
            IE = 0
      IF (I .LE. NLR) IR = 1
      IF (I .LE. NLE) IE = 1
      IF (I .GE. NRR) IR = 1
      IF (I .GE. NRE) IE = 1
            ZMUL = I - 2
            ZMUL = ZMUL + 0.5
COMMENT - COMPUTE DEFORMATIONS IN ELEMENT
            EP = DELTA/TH
            CUR1 = TAU1/H
            CUR2 = TAU2/H
COMMENT - ZERO ELEMENT THRUST, BENDING MOMENTS, AND STIFFNESS TERMS
            BM1 = 0.0
            BM2 = 0.0
            T1 = 0.0
            T2 = 0.0
            EI1 = 0.0
            EI2 = 0.0
            AE1 = 0.0
            AE2 = 0.0
            AEY1 = 0.0
            AEY2 = 0.0
            D(2,3) = 0.0
            D(3,2) = 0.0
COMMENT - INITIALISE THE PARAMETER THAT IS USED TO KEEP TRACK
COMMENT - OF THE (PRESCRIBED) SUBDIVIDED PIECES AND THEIR CUMULATIVE
COMMENT - POSITION ( APPLICABLE FOR INELASTIC CASE ONLY )
            ICUMU = 0
      DO 4000  J = 1, NCDAT
COMMENT - COMPUTE SECTION PROPERTIES AT MID-ELEMENT
            B = BCL(J) + ZMUL*DBCL(J)
            DP = DCL(J) + ZMUL*DDCL(J)
            Y = YCL(J) + ZMUL*DYCL(J)
            NSSLT = NSSL(J)
            NPTST = NPTS(NSSLT)
COMMENT - COMPUTE STRESS-STRAIN CURVE AT MID-ELEMENT ONLY FOR THE
COMMENT - NON-LINEAR ELASTIC CASE.
COMMENT - IF IT IS THE INELASTIC CASE , THEN THE SIG-EP CURVE AT
COMMENT - MID-ELEMENT IS THE SAME AS THAT AT THE FROM OR TO JOINT.
      IF ( NDIV(NALT,J) .EQ. 0 ) GO TO 2590
            NPTSM1 = NPTST - 1
      DO 2560 K = 1,NPTSM1
            SIGCCM(K) = SIGMAX(NSSLT,K) * SM(NALT,J)
            EPSCCM(K) = EPSIEL(NSSLT,K) * EM(NALT,J)
 2560 CONTINUE
COMMENT - THE ABOVE DO-LOOP CONTAINS COMPUTATIONS FOR THE INDIVIDUAL
COMMENT - COMPONENT SIG-EPS CURVES
COMMENT - NOW ALSO COMPUTE THE MAXIMUM SLOPE AT THE ORIGIN OF THE
COMMENT - VIRGIN SIG-EPS CURVE FOR USE IN STRAIN REVERSAL CHECK CASE
            SMSCL = SM(NALT,J)
            EMSCL = EM(NALT,J)
            SIGMA = NSIG(NSSLT,2) * SMSCL
            PSLON = NEPS(NSSLT,2) * EMSCL
           SLPMAX = SIGMA / PSLON
C
COMMENT - COMPUTE THE SMALL SLOPE FROM YLD PT, EPSILON STRAIN HARDENING,
COMMENT - SLOPE STRAIN HARDENING, ULTIMATE STRESS, ALPHA AND BETA FACTOR
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COMMENT - (FOR MILD STEEL )
C
COMMENT - IF IT IS NOT MILD STEEL, THEN THESE VALUES HAVE BEEN
COMMENT - PROPERLY ASSIGNED IN SUBROUTINE  SECUR.
C
                SMALL  = SMLSLP(NSSLT) * SMSCL / EMSCL
                EPHD   = EPSTHD(NSSLT) * EMSCL
                SLHD   = SLOPHD(NSSLT) * SMSCL / EMSCL
                SULT   = SIGULT(NSSLT) * SMSCL
                ALP    = ALPHA  (NSSLT)
                BET    = BETA   (NSSLT)
      GO TO 3910
 2590 CONTINUE
         DO 2600  K = 1,NPTST
                EPSTS(K) = EPSL(J,K)  + ZMUI*DEPSL(J,K)
 2600           SIGTS(K) = SIGL(J,K)  + ZMUL*DSIGL(J,K)
         IF (ISST  (J)  .EQ.  1)  GO TO 2650
         DO 2610 K = 1, NPTST
                EPST(K) = EPSTS(K)
                SIGT(K) = SIGTS(K)
 2610    CONTINUE
                ISSTT = 0
                NPT = NPTST
         GO TO 2700
 2650           EPST(NPTST) = EPSTS(1)
                SIGT(NPTST) = SIGTS(1)
         DO 2675  K = 2,NPTST
                KR = K + NPTST - 1
                KL = KR - 2*(K - 1)
                EPST(KR) =  EPSTS(K)
                EPST(KL) = -EPSTS(K)
                SIGT(KR) = SIGTS(K)
 2675           SIGT(KL) = -SIGTS(K)
                NPT = 2*(NPTST) - 1
                ISSTT = 1
 2700    CONTINUE
COMMENT - SUBDIVIDE PIPE PIECE INTO TEN EQUIVALENT RECTANGLES. (TWENTY
COMMENT - EQUAL RADIAL SEGMENTS WITH SEGMENTS IN OPPOSITE SIDES OF Y
COMMENT - AXIS COMBINED)
                NPP = 1
         IF (IRECT(NALT,J)  .EQ.  1)  NPP = 10
COMMENT - DO FOR EACH RECTANGLE IN PIECE
         DO 3900 IP = 1,NPP
         IF (NPP .EQ. 10) CALL PIPE (B,DP,Y,IP,NPP)
COMMENT - CALL FAEJR TO COMPUTE AXIAL THRUST, BENDING MOMENT AND
COMMENT - STIFFNESS TERMS FOR ONE RECTANGLE AT LOCATION OF FIRST
COMMENT - DISCRETE SPRING IN ELEMENT
       CALL        FAEJR (T,BM,EA,EI,AEY,ISSTT,NPT,Y,B,DP,EP,CUR1,IR,IE,
     2                    SH,GA,EPS,ELEMNT,SHCOEF,G)
COMMENT - ACCUMULATE VALUES FOR ALL RECTANGLES
              BM1 = BM1 + BM
              EI1 = EI1 + EI
              AEY1 = AEY1 + AEY
              AE1 = AE1 + EA
              T1 = T1 + T
COMMENT - CALL FAEJR TO COMPUTE AXIAL THRUST, BENDING MOMENT AND
COMMENT - STIFFNESS TERMS FOR ONE RECTANGLE AT LOCATION OF SECOND
COMMENT - DISCRETE SPRING IN ELEMENT
       CALL        FAEJR (T,BM,EA,EI,AEY,ISSTT,NPT,Y,B,DP,EP,CUR2,IR,IE,
     2                    SH,GA,EPS,ELEMNT,SHCOEF,G)
COMMENT - ACCUMULATE VALUES FOR ALL RECTANGLES
              BM2 = BM2 + BM
              EI2 = EI2 + EI
              AEY2 = AEY2 + AEY
              AE2 = AE2 + EA
              T2 = T2 + T
 3900    CONTINUE
      GO TO 4000
 3910 CONTINUE
COMMENT - INITIALISE THE FOLLOWING ADDITIONAL TERMS USED IN THE
COMMENT - INELASTIC CASE
         DO 3915 L = 1,2
              TTEM   (L) = 0.0
              BMTEM  (L) = 0.0
              AETEM  (L) = 0.0
              AEYTEM (L) = 0.0
              EITEM  (L) = 0.0
              TTMP   (L) = 0.0
              BMTMP  (L) = 0.0
              AETMP  (L) = 0.0
              AEYTMP (L) = 0.0
              EITMP  (L) = 0.0
 3915 CONTINUE
COMMENT - DO FOR EACH OF THE EQUALLY SUBDIVIDED RECTANGULAR PIECES
COMMENT - OF THE SINGLE INPUT J TH RECTANGLE ( OR PIPE IF APPLICABLE )
              NJ = NDIV(NALT,J)
         DO 3950 IJ = 1,NJ
              ICUMU = ICUMU + 1
         IF ( IRECT(NALT,J) .EQ. 1 ) GO TO 3920
COMMENT - SUBDIVIDE THE J TH PIECE AND SUPPLY B,DP,Y FOR EACH SUB-PIECE
              AIJ = IJ
              IF ( IJ .NE. 1 ) GO TO 3918
              ANJ = NJ
              DDP = DP / ANJ
              YC1 = Y + DP * 0.5 - DDP * 0.5
              DP = DDP
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 3918 Y = YC1 - ( AIJ - 1.0 ) * DP
      GO TO 3930
 3920 CALL       PIPE ( B, DP, Y, IJ, NJ )
 3930 CONTINUE
COMMENT - IF ALPHA=BETA=0, GO TO MASING SUBROUTINE
         IF ( ALPHA(NSSLT)+BETA(NSSLT) .LT. 1.0D-10 ) GC TO 3935
C
COMMENT - IF ALPHA#0, BETA=0  OR  ALPHA#BETA#0 , GO TO DEGRADATION CUM
COMMENT - YIELD GROWTH MCDEL.
C
      CALL        DEGROW (SIGHIS,STFHIS,Y,EP,CUR1,CUR2,IR,IE,
     2                    SIGCOM,EPSCOM,NPTSM1,ICUMU,I,SLPMAX,
     3                    SMALL,EPHD,SIHD,SULT,ALP,BET )
         GC TO 3938
 3935    CONTINUE
C
COMMENT - SUBROUTINE MASING EVALUATES THE HISTORY DEPENDENT
COMMENT - STRESS AND STIFFNESS, FOR THE SUB-PIECE AT THE LOCATION
COMMENT - OF BOTH THE HINGES 1&2, ACCCRDING TO MASING PATH
C
      CALL        MASING (SIGHIS,STFHIS,Y,EP,CUR1,CUR2,IR,IE,
     2                    SIGCOM,EPSCOM,NPTSM1,ICUMU,I,SLPMAX )
 3938    CONTINUE
         DO 3940 L = 1,2
              TTMP   (L) = TTMP   (L)  + SIGHIS(L)
              BMTMP  (L) = BMTMP  (L)  + SIGHIS(L)  * Y
              AETMP  (L) = AETMP  (L)  + STFHIS(L)
              AEYTMP (L) = AEYTMP (L)  + STFHIS(L)  * Y
              EITMP  (L) = EITMP  (L)  + STFHIS(L)  * Y * Y
 3940 CONTINUE
 3950 CONTINUE
              BDP = B * DP
         DO 3960 L = 1,2
              TTEM   (L) = TTEM   (L)  + TTMP   (L)  *  BDP
              BMTEM  (L) = BMTEM  (L)  + BMTMP  (L)  *(-BDP)
              AETEM  (L) = AETEM  (L)  + AETMP  (L)  *  BDP
              AEYTEM (L) = AEYTEM (L)  + AEYTMP (L)  *  BDP
              EITEM  (L) = EITEM  (L)  + EITMP  (L)  *  BDP
 3960 CONTINUE
              T1   = T1   + TTEM   (1)
              BM1  = BM1  + BMTEM  (1)
              AE1  = AE1  + AETEM  (1)
              AEY1 = AEY1 + AEYTEM (1)
              EI1  = EI1  + EITEM  (1)
              T2   = T2   + TTEM   (2)
              BM2  = BM2  + BMTEM  (2)
              AE2  = AE2  + AETEM  (2)
              AEY2 = AEY2 + AEYTEM (2)
              EI2  = EI2  + EITEM  (2)
 4000    CONTINUE
COMMENT - COMPUTE AVERAGE THRUST AND AXIAL STIFFNESS FOR ELEMENT
              TT = 0.5*(T1 + T2)
              AE(I) = 0.5*(AE1 + AE2)
COMMENT - COMPUTE INCREMENTAL FORCE DEFORMATION MATRIX FOR ELEMENT
              D(1, 1) = AE(I)/IH
              D(2, 2) = EI1/H
              D(3, 3) = EI2/H
              D(1, 2) = - AEY1/IH
              D(2, 1) = D(1, 2)
              D(1, 3) = - AEY2/IH
              D(3, 1) =  D(1, 3)
 4100    CONTINUE
COMMENT - STORE T1 CF THE FIRST NCNLINEAR ELEMENT  AND  T2 OF THE LAST
COMMENT - NONLINEAR ELEMENT , FOR USE LATER IN SUBROUTINE PRINT9 ,
COMMENT - WHERE THE HYSTERISIS CF MONITOR MEMBERS ARE RECORDED
COMMENT - ( HOWEVER FOR LINEAR MEMBERS AND MEMBERS WITH PIN END(S),
COMMENT - STORE ONLY TT CF BOTH THE FIRST AND LAST ELEMENTS, OR AS
COMMENT - APPLICABLE AT THE PIN END(S)
COMMENT - DC THIS ONLY FOR THE FINAL SCLUTICN OF THE MEMBER
         IF ( NITM(JJ) .NE. MNITM + 2 ) GO TC 4300
         IF ( INLOPT .EQ. 1 ) GO TO 4150
         IF ( I .NE. 2 ) GO TO 4120
              TTSLEF = TT
         GO TO 4300
 4120    CONTINUE
         IF ( I .NE. MP1 )  GO TO 4300
              TTSRGT = TT
         GO TO 4300
 4150    CONTINUE
         IF ( IPINL(ISTT) .NE. 1 ) GC TO 4160
         IF ( I .NE. 2 ) GO TO 4200
              TTSLEF = TT
         GO TO 4300
 4160    CONTINUE
         IF ( I .NE. NLE + 1 ) GC TO 4200
              TTSLEF = T1
         GO TO 4300
 4200    CONTINUE
         IF ( IPINR(ISTT) .NE. 1 ) GC TO 4260
         IF ( I .NE. MP1 ) GC TO 4300
              TTSRGT = TT
         GO TO 4300
 4260    CONTINUE
         IF ( I .NE. NRE - 1 ) GC TO 4300
              TTSRGT = T2
 4300    CONTINUE
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      RETURN
      END


*********************************** SUBROUTINE ***********************************
      SUBROUTINE PIPE (B,DP,Y,IP,NPP)
COMMENT - SUBROUTINE PIPE IS CALLED NPP TIMES BY SUBROUTINE FAEREV FOR
COMMENT - THIN WALLED PIPE PIECES- EACH TIME SUBROUTINE PIPE FURNISHES
COMMENT - THE DEPTH AND THE WIDTH OF A RECTANGLE WHICH IS EQUIVALENT TO
COMMENT - TWO EQUAL RADIAL SEGMENTS OF THE PIPE PIECE
      IMPLICIT REAL*8 (A-H,O-Z)
      DOUBLE PRECISION DARCOS,DSIN,DCOS
         IF (IP  .NE. 1) GO TO 10
               RA = 0.5*(B - DP)
               T = DP
               YC = Y
               DTE = DARCOS(-1.0D+00)/NPP
   10          ZIP = IP
               ZIP = ZIP - 0.5
               TE =  DTE*ZIP
               DP = RA*DSIN(TE)*DTE
               B = 2.*T/DSIN(TE)
               Y = YC + RA*DCOS(TE)
      RETURN
      END


*********************************** SUBROUTINE ***********************************
      SUBROUTINE FAEJR (T,BM,EA,EI,AEY,ISSTT,NPT,Y,B,DP,EP,CUR,IR,IE,
     2                 SH,GA,EPS,ELEMNT,SHCOEF,G)
COMMENT - SUBROUTINE FAEJR SUBDIVIDES THE INPUT RECTANGLES INTO
COMMENT - SUB-RECTANGLES EACH OF WHICH HAS  A LINEAR STRESS-STRAIN
COMMENT - CURVE OVER IT, FOR THE NUMERICAL INTEGRATION OF THE
COMMENT - STRESS- STRAIN CURVE TO FIND AXIAL THRUST T, BENDING MOMENT M,
COMMENT - AXIAL STIFFNESS EA, BENDING STIFFNESS EI, AND AXIAL BENDING
COMMENT - STIFFNESS AEY
      IMPLICIT REAL*8 (A-H,O-Z)
      DIMENSION DA(22),DI(22),YY(22),EPC(22)
      COMMON /BLOC15/ EPST(21),    SIGT(21),    EPSTS(11),  SIGTS(11)
      COMMON /BLK7/ INLOPT,IFAE,KOFFJ,KOFFOW,KOFFSE
               DATA SHEAR /5HSHEAR/
COMMENT - COMPUTE STRAIN AND Y DISTANCES FOR TOP AND BOTTOM OF INPUT
COMMENT - RECTANGLE
               YB = Y - 0.5*DP

               YT = YB + DP
               EPB = EP - YB*CUR
               EPT = EP - YT*CUR
               R =   1.0
      IF (EPB .LE. EPT) GO TO 100
COMMENT - REVERSE FOR POSITIVE CURVATURE
               ET = EPB
               EPB = EPT
               EPT = ET
               YTT = YT
               YT = YB
               YB = YTT
               R = -1.0
  100 CONTINUE
COMMENT - FIND FIRST POINT ON STRESS-STRAIN CURVE ON OR BELOW RECTANGLE
      DO 200 K = 1,NPT
      IF (EPB .GE. EPST(K)) GO TO 200
               NN1 = K - 1
      GO TO 300
  200 CONTINUE
               NN1 = NPT
  300 CONTINUE
               NNP = NN1 + 1
      IF (NNP .GT. NPT) GO TO 410
COMMENT -  FIND FIRST POINT ABOVE RECTANGLE
      DO 400 K = NNP, NPT
      IF (EPT .GT. EPST(K)) GO TO 400
               NN2 = K
      GO TO 500
  400 CONTINUE
  410          NN2 = NPT + 1
  500 CONTINUE
COMMENT - COMPUTE NUMBER OF SUBRECTANGLES
               NN3 = NN2 - NN1
COMMENT - NPTT POINTS USED TO ENTER STRESS STRAIN CURVE
               NPTT = NPT
COMMENT - SYMMETRICAL CURVE USE ONLY POSITIVE BRANCH
               IF (ISSTT .EQ. 1) NPTT = (NPT + 1)/2
COMMENT - ZERO THRUST,BENDING MOMENT AND STIFFNESS TERMS
               T = 0.0
               BM = 0.0
               EA = 0.0
               AEY = 0.0
               EI = 0.0
      IF (NN3 .NE. 1)  GO TO 1200
COMMENT - CALCULATE PROPERTIES FOR WHOLE RECTANGLE
               DA(1) = B*DP
               DI(1) =       B*DP**3/12.
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                YY(1) = Y
                EPC(1) = 0.5*(EPB + EPT)
         GO TO 4000
COMMENT - CALCULATE PROPERTIES FOR FIRST RECTANGLE
 1200           DD = -R*(EPST(NNP) - EPB)/CUR
                DA(1) = B*DD
                DI(1) =          B*DD**3/12.
                YY(1) = YB + 0.5*DD*R
                EPC(1) = (EPB + EPST(NNP))*0.5
                YTT = YB + DD*R
COMMENT - CALCULATE PROPERTIES FOR LAST SUBRECTANGLE
                DD =-R*(EPT - EPST(NN2 - 1))/CUR
                DA(NN3) = B*DD
                DI(NN3) =          B*DD**3/12.
                YY(NN3) = YT - 0.5*DD*R
                EPC(NN3) = (EPT + EPST(NN2 - 1))*0.5
         IF (NN3 .EQ. 2) GO TO 4000
                NN4 = NN3 - 1
                K = NN1
COMMENT - CALCULATE PROPERTIES FOR REMAINING SUBRECTANGLES
          DO 3000 N = 2,NN4
                K = K + 1
                DD =-R*(EPST(K + 1) - EPST(K))/CUR
                DA(N) = B*DD
                DI(N) =        B*DD**3 /12.
                YY(N) = YTT + 0.5*DD*R
                EPC(N) = 0.5*(EPST(K + 1) + EPST(K))
                YTT = YTT + DD*R
 3000     CONTINUE
 4000     CONTINUE
COMMENT -  DO FOR EACH SUBRECTANGLE
                DO 5000  N = 1,NN3
                EPT = EPC(N)
COMMENY - ZERO STRAIN USED TO ENTER CURVE WITH FOR RIGID OR LINEAR
COMMENT - ELEMENT
          IF (IR .EQ. 1 .OR. IE .EQ. 1) EPT = 0.0
COMMENT - CALL CURVE TO FIND NEGATIVE OF SLOPE OF STRESS-STRAIN CURVE
COMMENT --ACOMPUTE AND ACCUMULATE T,BM,EA,AE,AEY
COMMENT - AND STRESS AT CENTEROID OF SUBRECTANGLE SIGMA
      CALL      CURVE (SIGTS,EPSTS,EPT,    NPTT,ISSTT,SIG,S2,KOFFSE)
                E = -S2
COMMENT - E = 10*E FOR RIGID ELEMENT
          IF (IR.EQ. 1)  E = 10.*E
          IF (IR .EQ. 1 .OR. IE .EQ. 1)  SIG = SIG + E*EPC(N)
                DT = SIG*DA(N)
                DAE = E*DA(N)
                EA = EA + DAE
                EI = EI + E*(DI(N) + DA(N)*YY(N)**2)
                AEY = AEY + DAE*YY(N)
                T = T + DT
                BM = BM + DI(N)*E*CUR - DT*YY(N)
 5000     CONTINUE
          IF (ELEMNT .NE. SHEAR) GO TO 9000
COMMENT - LINEAR STRESS-STRAIN CURVE IS ASSUMED FOR SHEAR
                GA = G*B*DP*SHCOEF
                SH = GA*EPS
 9000     CONTINUE
      RETURN
      END


*********************************** SUBROUTINE ***********************************
      SUBROUTINE CURVE (QQ, WW, WJ, NPT, ISYM, QJ, S2, KOFFC)
COMMENT - SUBROUTINE CURVE INTERPOLATES ALONG A STRESS-STRAIN CURVE
COMMENT - TO FIND THE STRESS QJ CORRESPONDING TO THE STRAIN WJ AND
COMMENT - THE NEGATIVE OF THE SLOPE OF THE CURVE S2 BETWEEN ADJACENT
COMMENT - POINTS ON THE CURVE - IF WJ IS OFF-CURVE, KOFFC IS SET
COMMENT - EQUAL TO 1 .  IF WJ IS EXACTLY ON A POINT, THE SLOPE OF THE
COMMENT - SEGMENT TO THE LEFT (DECREASING DEFORMATION) IS USED
COMMENT - FOR JOINT-SUPPORT AND MEMBER-SUPPORT CURVES, SEPARATE
COMMENT - SUBROUTINES HAVE BEEN WRITTEN TO ACCOUNT FOR THE INELASTIC
COMMENT - (HISTORY DEPENDENT) BEHAVIOUR.
COMMENT - A SPECIAL SUBROUTINE IS ALSO WRITTEN TO PERFORM A SIMILAR
COMMENT - HISTORY DEPENDENT ANALYSIS OF STRESS-STRAIN CURVE,
COMMENT - BUT WITH SOME LIMITATIONS FOR THE PRESENT
      IMPLICIT REAL*8 (A-H,O-Z)
      DIMENSION QQ(11),  WW(11)
                NEG = 0
          IF (ISYM .EQ. 1 .AND. WJ .LT. 0.0) GO TO 2100
          GO TO 2200
 2100     WJ = - WJ
                NEG = 1
 2200     CONTINUE
          DO 3040 NP = 2,NPT
          IF (WJ - WW(NP)) 3045,3055,3040
 3040     CONTINUE
                NP = NPT
          GO TO 3050
 3045     IF (WJ - WW(1)) 3050,3055,3055
 3050           KOFFC = 1
 3055           NP = NP - 1
                S2 = - (QQ(NP + 1) - QQ(NP))/(WW(NP + 1) - WW(NP))
                QJ = QQ(NP) - S2*(WJ - WW(NP))
          IF (NEG .EQ. 0) GO TO 4300
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               QJ = -QJ
               MJ = -MJ
 4300     CONTINUE
      RETURN
      END


 ********************************** SUBROUTINE *********************************
      SUBROUTINE MASING (SIGHIS,STFHIS,Y,EP,CUR1,CUR2,IR,IE,
     2            SIGCOM,EPSCOM,NPTSM1,ICUMU,I,SLPMAX )
COMMENT - SUBROUTINE  SIGSTF  DETERMINES THE HISTORY DEPENDENT
C         STRESS SIGHIS, AND STIFFNESS STFHIS, AT THE TWO HINGE
C         POSITIONS OF AN ELEMENT I,AND FOR ONE SUBDIVIDED PIECE ONLY
C         OF THE CROSS SECTION.
      IMPLICIT REAL * 8 (A-H , O-Z)
      DIMENSION SIGHIS(2), STFHIS(2)
      DIMENSION EPSCOM(10), SIGCOM(10)
      COMMON /BLOCK4/ FOMM(50,6),SMC(50,21),IST(50),    LT(50),
     2  JT1(50),     JT2(50),     NITM(50),   IMM(50),   IMC(50)
      COMMON /BLK1/  TOL,     ELEMNT,NJST,   KEEP3C,NCD3C,
     2             KEEP2, KEEP3A,KEEP3E,KEEP4A,KEEP4B,KEEP4C,KEEP5A,
     3             KEEP5B,KEEP5C,KEEP5D,KEEP6, KEEP7, NCD2,   NCD3A,
     4             NCD3B, NCD4A, NCD4B, NCD4C, NCD5A, NCD5B, NCD5C,
     5             NCD5D, NCD6,  NCD7,  IP8,   IP9,   IP10,  ITYPE,
     6             IABAN, IFORM, NM,    NJT,   NST,   NLT,   M,
     7             MP1,   MP2,   ISIT,  LTT,   ITYPEL,IDJ,   NSTL
      COMMON /BLK5/ NFSUB,NITP,N1,N2
      COMMON /BLK7/ INLOPT,IFAE,KCFFJ,KOFFQW,KOFFSE
      COMMON/ITC/  ERR1,ERR2,ER1,ER2,DTI,CM,NTI,MM(20),MJ(20),MNITF,
     2             MNITM,NSMJ,NSMM
      COMMON /NIT/  APROB
      COMMON /SKT6/        NITERM(50), INDEX
      COMMON /SKT13/       EPR1S(21,10,3),EPRT1S(21,10,3),
     2                     EPR2S(21,10,3),EPRT2S(21,10,3)
      COMMON /SKT14 / IRV(21,2,10),                  FOMOLD(50,6),
     2                IRVRSE,           ITAPE,       N3
      COMMON /SKT15/  JJ
      COMMON /SKT18/  NCHECK
      COMMON /SKT22/  TIME, JT, IRDYN, IRSTEP(71)
      COMMON /SKT33/  NRGION(21,2,10)
   25 FORMAT ( 18H **NOTE** MEMBER =,I4,11H, ELEMENT =,I3,
     2   9H, HINGE =,I2, 9H, PIECE =,I3,/,
     3  10H STRAIN = ,1PE10.3,/,  9H STRESS =,1PE10.3,/,
     4  12H STIFFNESS = ,1PE10.3)
               DATA SHEAR /5HSHEAR/
               NHINGE = 1
         IF (ELEMNT .NE. SHEAR) NHINGE=2
         DO 2000 L = 1,NHINGE
         IF ( L .EQ. 1 ) STRAIN = EP - CUR1 * Y
         IF ( L .EQ. 2 ) STRAIN = EP - CUR2 * Y
         IF ( IR .EQ. 1 .OR. IE .EQ. 1 ) STIFF = SLPMAX
         IF ( IR .EQ. 1 .OR. IE .EQ. 1 ) GO TO 1250
               STRESS = 0.0
               STIFF  = 0.0
         DO 1200 K = 1,NPTSM1
               SLOPE = SIGCOM(K)  / EPSCOM(K)
         IF ( L .NE. 1 ) GO TO 100
               ER  = EPR1S (I,ICUMU,K)
               ERT = EPRT1S (I,ICUMU,K)
      GO TO 200
  100 CONTINUE
               ER  = EPR2S  (I,ICUMU,K)
               ERT= EPRT2S  (I,ICUMU,K)
  200 CONTINUE
         IF ( DABS (STRAIN-ER)  .GE.  (EPSCOM(K)-5.0D-10) ) GO TO 500
C                             LINEAR ZONE ( BEGIN )
               STIFF = STIFF + SLOPE
               SO    = SLOPE *(STRAIN-ER)
         IF ( NCHECK .NE. 1 ) GO TO 450
COMMENT - ONLY FIRST COMPONENT NEED TO BE MONITORED FOR REVERSAL.
         IF ( K      .NE. 1 ) GO TO 450
         IF ( NRGION(I,L,ICUMU)  .EQ. 0 ) GO TO 450
               IRV ( I, L, ICUMU ) = 1
         GO TO 1400
  450    CONTINUE
COMMENT - DURING ITERATION PROCESS IT IS POSSIBLE THAT THE STRAIN
COMMENT - RIDES INTO PLASTIC RANGE, AND THEN COMES INTO THE ELASTIC
COMMENT - RANGE. IN SUCH A CASE, THE TEMPORARY RESIDUAL STRAIN MUST BE
COMMENT - PROPERLY RE-FIXED IN VALUE, SO THAT IMPROPER VALUES ARE NOT
COMMENT - ERRONEOUSLY USED IN THE NEXT PROBLEM.
COMMENT - HENCE THE FOLLOWING STATEMENT
               ERT = ER
         IF ( IFAE .EQ. 1 ) GO TO 460
         IF ( K    .NE. 1 ) GO TO 460
               NRGION(I,L,ICUMU) =  0
  460    CONTINUE
C                             LINEAR ZONE ( END )
         GO TO 1000
  500 CONTINUE
         IF ( STRAIN .GT. ER ) GO TO 600
C                             NEGATIVE YIELD ZONE ( BEGIN )
               SO    = -SIGCOM(K)
         IF ( NCHECK .NE. 1 ) GO TO 550
         IF ( K      .NE. 1 ) GO TO 550
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      IF ( NRGION(I,L,ICUMU) .NE. 1 ) GO TO 550
           IRV ( I, L, ICUMU ) = 1
      GO TO 1400
550   CONTINUE
           ERT =  STRAIN + EPSCOM(K)
      IF ( IFAE .EQ. 1 ) GO TO 560
      IF ( K    .NE. 1 ) GO TO 560
           NRGION(I,L,ICUMU) = -1
560   CONTINUE
C                    NEGATIVE YIELD ZONE ( END )
   GO TO 1000
C                    POSITIVE YIELD ZONE ( BEGIN )
600        SO   = SIGCOM(K)
      IF ( NCHECK .NE. 1 ) GO TO 650
      IF ( K      .NE. 1 ) GO TO 650
      IF ( NRGION(I,L,ICUMU) .NE. -1) GO TO 650
           IRV ( I, L, ICUMU ) = 1
      GO TO 1400
650   CONTINUE
           ERT = STRAIN - EPSCOM(K)
      IF ( IFAE .EQ. 1 ) GO TO 660
      IF ( K    .NE. 1 ) GO TO 660
           NRGION(I,L,ICUMU) = +1
660   CONTINUE
C                    POSITIVE YIELD ZONE ( END )
1000       STRESS = STRESS + SO
      IF ( L .NE. 1 ) GO TO 1100
           EPR1S (I,ICUMU,K) = ER
           EPRT1S(I,ICUMU,K) = ERT
      GO TO 1150
1100 CONTINUE
           EPR2S (I,ICUMU,K) = ER
           EPRT2S(I,ICUMU,K) = ERT
1150  CONTINUE
1200 CONTINUE
C                    ONLY IN STATIC ANALYSIS
C     IFAE=1 THIS SUBROUTINE IS INSIDE         FORMST
C          0 THIS SUBROUTINE IS INSIDE         MEMSOL
      IF ( ITYPE .GE. 3 ) GO TO 1210
      IF ( IFAE .EQ. 1 ) GO TO 1220
      IF (NITF .EQ. 2 .AND. NITERM(JJ) .EQ. 1 ) GO TO 1220
      GO TO 1250
1210  CONTINUE
      IF ( IRDYN .EQ. 1 ) GO TO 1220
     IF(IRSTEP(JT).EQ.1.AND.NITF.EQ.1.AND.NITERM(JJ).EQ.1)GO TO 1220
      GO TO 1250
1220  CONTINUE
      IF ( IRV(I,L,ICUMU) .EQ. 0 ) GO TO 1250
           STIFF = SLPMAX
      IF ( ITYPE .LE. 2 ) GO TO 1240
      IF ( IRDYN .EQ. 1 ) GO TO 1250
     IF(IRSTEP(JT).EQ.1.AND.NITF.EQ.1.AND.NITERM(JJ).EQ.1)
     2     IRV(I,L,ICUMU) = 0
      GO TO 1250
1240  CONTINUE
      IF ( IFAE .EQ. 0 ) IRV(I,L,ICUMU) = 0
1250  CONTINUE
COMMENT - STIFF = 10 * STIFF FOR RIGID ELEMENT
      IF ( IR .EQ. 1 ) STIFF = 10.0 * STIFF
      IF ( IR .EQ. 1 .OR. IE .EQ. 1 ) GO TO 1300
   GO TO 1400
1300 CONTINUE
           STRESS = STIFF * STRAIN
1400 CONTINUE
           SIGHIS (L) = STRESS
           STFHIS (L) = STIFF
COMMENT - OUTPUT MESSAGE (DURING FINAL MEMBER SOLUTION ONLY) IF THE
COMMENT - STRAIN EXCEEDS THE LAST STRAIN ORDINATE OF VIRGIN CURVE.
      IF ( NITM(JJ) .NE. MNITM+2 ) GO TO 1500
      IF (DABS(STRAIN) .LT. EPSCOM(NPTSM1) ) GO TO 1500
      IF ( NPTSM1 .EQ. 1 ) GO TO 1500
   PRINT 25, JJ,I,L,ICUMU,STRAIN,SIGHIS(L),STFHIS(L)
1500  CONTINUE
      IF ( IR .EQ. 1 .OR. IE .EQ. 1 ) GO TO 2000
      IF ( NCHECK .NE. 1 ) GO TO 1800
           IRVRSE = IRVRSE + IRV ( I, L, ICUMU )
1800  CONTINUE
2000 CONTINUE
     RETURN
     END


*********************************** SUBROUTINE ***********************************
      SUBROUTINE DEGROW ( SIGHIS,STFHIS,Y,EP,CUR1,CUR2,IR,IE,
     2                SIGCOM,EPSCOM,NPTSM1,ICUMU,I,SLPMAX,
     3                SMALL,EFHD,SLHD,SULT,ALP,BET )
COMMENT - SUBROUTINE DEGROW CALCULATES THE HISTORY DEPENDENT
C         STRESS SIGHIS, AND STIFFNESS STFHIS, AT THE TWO HINGE
C         POSITIONS OF AN ELEMENT I, AND FOR ONE SUBDIVIDED PIECE
C         OF THE CROSS SECTION .
C         THIS SUBROUTINE USES THE SPECIAL DEGRADATION CUM YIELD GROWTH
C         MODEL DEVELOPED FOR MILD STEEL.
C         FOR MATERIALS OTHER THAN MILD STEEL, THIS SUBROUTINE CAN
C         HANDLE A GENERAL SYMMETRIC VIRGIN CURVE , WITH A PRESCRIBED
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C         DEGREE OF DEGRADATION CNLY ( NO YIELD GROWTH )
C         AS A PARTICULAR CASE, THIS SUBROUTINE CAN ALSO HANDLE
C         THE MASING MODEL ( NO DEGRADATION, NO TIELD GROWTH ), BUT
C         IS NOT ECONOMICAL TC DO THIS. HENCE A SEPERATE SUBROUTINE
C         IS WRITTEN FOR THE MASING MCDEL.
      IMPLICIT REAL * 8 ( A-H, O-Z )
      DIMENSION SIGHIS(2), STFHIS(2)
      DIMENSION EPSCOM(10), SIGCOM(10)
      COMMON /BLOCK4/ FOMM(50,6),SMC(50,21),IST(50),   LT(50),
     2    JT1(50),      JT2(50),        NITM(50),   IMM(50),    IMC(50)
      COMMON /BLK1/  TOL,     ELEMNT,NJST,  KEEP3C,NCD3C,
     2        KEEP2, KEEP3A,KEEP3B,KEEP4A,KEEP4B,KEEP4C,KEEP5A,
     3        KEEP5B,KEEP5C,KEEP5D,KEEP6, KEEP7, NCD2,  NCD3A,
     4        NCD3B, NCD4A, NCD4B, NCD4C, NCD5A, NCD5B, NCD5C,
     5        NCD5D, NCD6,  NCD7,  IP8,   IP9,   IP10,  ITYPE,
     6        IABAN, IFORM, NM,    NJT,   NST,   NLT,   M,
     7        MP1,   MP2,   ISTT,  LTT,   ITYPEL,IDJ,   NSTL
      COMMON /BLK5/ NFSUB,NITF,N1,N2
      COMMON /BLK7/ INLOPT,IFAE,KOFFJ,KOFFQH,KOFFSE
      COMMON/ITC/ ERR1,ERR2,ER1,ER2,DTI,CM,NTI,MM(20),MJ(20),MNITF,
     2            MNITM,NSMJ,NSMM
      COMMON / NIT/ APROB
      COMMON /SKT6/        NITERM(50), INDEX
      COMMON /SKT13/       EPR1S(21,10,3),EPRT1S(21,10,3),
     2                     EPR2S(21,10,3),EPRT2S(21,10,3)
      COMMON /SKT14 / IRV(21,2,10),                     FOMOLD(50,6),
     2                IRVRSE,       ITAPE,              N3
      COMMON /SKT15/ JJ
      COMMON /SKT18/ NCHECK
      COMMON /SKT22/ TIME, JT, IRDYN, IRSTEP(71)
      COMMON /SKT30/ MSTIF(25), ELOAD(25), MODEL(25)
      COMMON /SKT32/ EPBF1 (21,10,3), EPBFT1(21,10,3), SLBF1 (21,10,3),
     2               SLBFT1(21,10,3), EPBF2 (21,10,3), EPBFT2(21,10,3),
     3               SLBF2 (21,10,3), SLBFT2(21,10,3),
     4               EPSMAX(21,2,10), EPSMIN(21,2,10), EPSPRE(21,2,10),
     5               YGROW (21,2,10), YTGROW(21,2,10)
      COMMON /SKT33/ NRGICN(21,2,10)
   25 FORMAT ( 18H **NOTE** MEMBER =,I4,11H, ELEMENT =,I3,
     2  9H, HINGE =,I2, 9H, PIECE =,I3,/,
     3 10H STRAIN = ,1PE10.3,/, 9H STRESS =,1PE10.3,/,
     4 12H STIFFNESS = ,1PE10.3)
            DATA SHEAR /5HSHEAR/
            NHINGE = 1
         IF (ELEMNT .NE. SHEAR) NHINGE=2
         DO 2000 L = 1,NHINGE
         IF ( L .EQ. 1 ) STRAIN = EP - CUR1 * Y
         IF ( L .EQ. 2 ) STRAIN = EP - CUR2 * Y
         IF ( IR .EQ. 1 .OR. IE .EQ. 1 ) STIFF = SLPMAX

         IF ( IR .EQ. 1 .OR. IE .EQ. 1 ) GO TO 1250
         IF ( MODEL(ISTT) .NE. 2 ) GO TO 55
            YGR  = YGRCW (I,I,ICUMU)
            YTGR = YTGROW(I,L,ICUMU)
   55    CONTINUE
            STRESS = 0.0
             STIFF = 0.0
            TEMP9 = EPSMAX(I,L,ICUMU)
            TEMP0 = EPSMIN(I,L,ICUMU)
         DO 1200 K = 1,NFTSM1
         IF ( TEMP9 .LT. EPSCOM(K) ) TEMP9 = EPSCOM(K)
         IF ( TEMP0 .GT.-EPSCOM(K) ) TEMP0 =-EPSCOM(K)
            SLOPE = SIGCOM(K) / EPSCOM(K)
         IF ( DET .GT. 1.0D-15 ) GO TC 60
            YGR  = SIGCOM(K)
            YTGR = SIGCOM(K)
   60    CONTINUE
         IF ( L .NE. 1 ) GO TO 100
            ER     = EPR1S (I,ICUMU,K)
            ERT    = EPRT1S(I,ICUMU,K)
            EPBFR  = EPBF1 (I,ICUMU,K)
            EPBFRT = EPBFT1(I,ICUMU,K)
            SLBFR  = SLBF1 (I,ICUMU,K)
            SLBFRT = SLBFT1(I,ICUMU,K)
         GO TO 200
  100    CONTINUE
            ER     = EPR2S (I,ICUMU,K)
            ERT    = EPRT2S(I,ICUMU,K)
            EPBFR  = EPBF2 (I,ICUMU,K)
            EPBFRT = EPBFT2(I,ICUMU,K)
            SLBFR  = SLBF2 (I,ICUMU,K)
            SLBFRT = SLBFT2(I,ICUMU,K)
  200    CONTINUE
C        REFER FLOW CHART OF FIGURE 3.4 OF DISSERTATION FOR DETAILS
C        ABOUT THE REGIONS MENTICNED BELCW IN THIS SUBROUTINE
C        REGION 1  ( UPTO STATEMENT # 320 )
         IF ( TEMP9 .GT.  EPSCOM(K) ) GO TO 320
         IF ( TEMP0 .LT. -EPSCOM(K) ) GO TC 320
            YTGR    = SIGCOM(K)
         IF ( STRAIN.GT.  EPSCOM(K) ) GO TC 320
         IF ( STRAIN.LT. -EPSCOM(K) ) GO TC 320
         IF ( NCHECK .NE. 1 )         GO TO 310
         IF ( K      .NE. 1 )         GO TO 310
         IF ( NRGICN(I,L,ICUMU) .EQ. 0 ) GO TO 310
            IRV(I,L,ICUMU) = 1
         GO TO 1400
  310    CONTINUE
            EO      = SLOPE
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            S0     = SLOPE * STRAIN
            SLBFRT = SMALL
         IF ( STRAIN .LT. 0.0 ) GO TO 315
            EPBFRT = EPSCOM(K)
         GO TO 317
  315    CONTINUE
            EPBFRT = -EPSCOM(K)
  317    CONTINUE
         IF ( IFAE   .EQ. 1 ) GO TO 484
         IF ( K      .NE. 1 ) GO TO 484
            NRGION(I,L,ICUMU) = 0
         GO TO 484
  320    CONTINUE
         IF ( (STRAIN-EPBFR) .LT.-1.0D-15 ) GO TO 405
C        REGIONS OF POSITIVE VELOCITY
         IF ( NCHECK .NE. 1 )                  GO TO 331
         IF ( K      .NE. 1 )                  GO TO 331
         IF ( NRGION(I,L,ICUMU) .NE. -1 )      GO TO 331
            IRV(I,L,ICUMU) = 1
         GO TO 1400
  331    CONTINUE
         IF ( STRAIN .LT. ER ) GO TO 396
C        REGIONS 8 , 9 , 2 AND THEIR PRIMED EQUIVALENTS
         IF ( EPBFR  .GT. ER )      GO TO 350
C        REGION 8 FOLLOWS FROM REGION 7 . SO ESTABLISH REGION 8
         IF ( BET    .LT. 1.0D-15) GO TO 346
C        GROWTH IN THE YIELD STRESS LEVEL IS EFFECTIVE NOW (NEXT 10 ST)
         IF ( TEMP9 .GT. EPSCOM(K))GO TO 340
         IF ( TEMP0 .LT.-EPSCOM(K))GO TO 340
            YTGR   = SIGCOM(K)
         GO TO 346
  340    IF ( TEMP9+TEMP0.GT.0.0)  GO TO 343
            YTGR = SIGCOM(K) + BET * SLOPE * TEMP0 * TEMP0
         GO TO 344
  343       YTGR = SIGCOM(K) + BET * SLOPE * TEMP9 * TEMP9
  344    IF ( YTGR   .LE. SULT   ) GO TO 346
            YTGR   = SULT
  346       E0 = SIGCOM(K) / ( EPSCOM(K) +ALP*(TEMP9-ER-EPSCOM(K)) )
            S0 = E0 * ( STRAIN - ER )
         GO TO 356
C        REGION 8, 9 OR 2 FOLLOWS 3' (OR 2 FOLLOWS 3). USE STORED VALUE
  350       E0 = SLBFR
            S0 = SLOPE * (EPBFR-ER ) + SLBFR * ( STRAIN-EPBFR )
            YTGR = YGR
         IF ( DABS (SLBFR-SMALL) .LT. 1.0D-15 ) GO TO 380
         IF ( SLBFR .LT. 1.0D-15 )              GO TO 380
  356    CONTINUE
C        CHECK IF OVERFLOW INTO REGION 9 ?
         IF ( S0 .LE. SIGCOM(K) )  GO TO 380
C        ESTABLISH REGION 9
         IF ( E0 .LE. 1.0D-15 )      GO TO 364
            Z = STRAIN - ( S0 - SIGCOM(K) ) / E0
         IF ( DABS(TEMP9-Z) .LE. 1.0D-15 ) GO TO 364
            E0 = ( YTGR - SIGCOM(K) ) / ( TEMP9 - Z )
            S0 = SIGCOM(K) + E0 * ( STRAIN - Z )
  364    CONTINUE
C        CHECK IF OVERFLOW INTO REGION 2 ?
         IF ( S0 .LT. YTGR ) GO TO 380
C        ESTABLISH REGION 2
            S0 = YTGR + SMALL * ( STRAIN - TEMP9 )
            E0 = SMALL
C        CHECK IF MONOTONIC EXCURSION INTO +VE STRAIN HARDENING ?
  380    IF ( YTGR   .GT. SIGCOM(K) ) GO TO 387
         IF ( STRAIN .LT. EPHD )      GO TO 387
C        FOLLOW +VE BRANCH OF VIRGIN STRAIN HARDENING
            E0 = SLHD
            S0 = SIGCOM(K) + SMALL * ( EPHD-EPSCOM(K) )
     2                     + SLHD  * ( STRAIN-EPHD )
  387    IF ( S0 .LT. SULT )          GO TO 390
            S0 = SULT
            E0 = 0.0
  390       EPBFRT = STRAIN
            SLBFRT = E0
         IF ( IFAE .EQ. 1 ) GO TO 484
         IF ( K    .NE. 1 ) GO TO 484
            NRGION(I,L,ICUMU) = +1
         GO TO 484
C        ELASTIC REGION 7 ( OR 7' )
  396       E0 = SLOPE
            S0 = SLOPE * ( STRAIN - ER )
            EPBFRT = EPBFR
            SLBFRT = SLBFR
            YTGR   = YGR
         IF ( IFAE .EQ. 1 ) GO TO 484
         IF ( K    .NE. 1 ) GO TO 484
            NRGION(I,L,ICUMU) = 0
         GO TO 484
  405    CONTINUE
C        REGIONS OF NEGATIVE VELOCITY
         IF ( NCHECK .NE. 1 )                  GO TO 411
         IF ( K      .NE. 1 )                  GO TO 411
         IF ( NRGION(I,L,ICUMU) .NE. +1 )      GO TO 411
            IRV(I,L,ICUMU) = 1
         GO TO 1400
  411    CONTINUE
         IF ( ER     .LT. STRAIN ) GO TO 476
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C        REGIONS 4 , 5 , 6 AND THEIR PRIMED EQUIVALENTS
         IF ( EPBFR  .LT. ER )        GO TO 430
C        REGION 4 FOLLOWS FROM 3 - SO ESTABLISH REGION 4
         IF ( BET .LT. 1.0D-15 )   GO TO 426
C        GROWTH IN THE YIELD STRESS LEVEL IS EFFECTIVE NOW (NEXT 10 ST)
         IF ( TEMP9 .GT. EPSCOM(K)) GO TO 420
         IF ( TEMP0 .LT.-EPSCOM(K)) GO TO 420
              YTGR    = SIGCOM(K)
         GO TO 426
  420    IF ( TEMP9+TEMP0 .GT. 0.0 ) GO TO 423
              YTGR = SIGCOM(K) + BET * SLOPE * TEMP0 * TEMP0
         GO TO 424
  423         YTGR = SIGCOM(K) + BET * SLOPE * TEMP9 * TEMP9
  424    IF ( YTGR .LE. SULT ) GO TO 426
              YTGR = SULT
  426         E0   = SIGCOM(K)/( EPSCOM(K)+ALP*(ER-EPSCOM(K)-TEMP0) )
              S0   = E0 * ( STRAIN - ER )
         GO TO 436
  430         E0   = SLBFR
C        REGION 4, 5 OR 6 FOLLOWS 7' (OR 6 FOLLOWS 7). USE STORED VALUE
              S0   = -(SLOPE*(ER-EPBFR) + SLBFR*(EPBFR-STRAIN))
              YTGR = YGR
         IF ( DABS(SLBFR-SMALL) .LT. 1.0D-15 ) GO TO 460
         IF ( SLBFR .LT. 1.0D-15 )             GO TO 460
  436    CONTINUE
C        CHECK IF OVERFLOW INTO REGION 5 ?
         IF ( S0 .GE. -SIGCOM(K) ) GO TO 460
C        ESTABLISH REGION 5
         IF ( E0 .LE. 1.0D-15 )     GO TO 444
              Z = STRAIN - ( S0+SIGCOM(K) ) / E0
         IF ( DABS(TEMP0-Z) .LE. 1.0D-15 ) GO TO 444
              E0 = ( YTGR-SIGCOM(K) ) / ( Z-TEMP0 )
              S0 = -SIGCOM(K) + E0 * (STRAIN-Z )
  444    CONTINUE
C        CHECK IF OVERFLOW INTO REGION 6 ?
         IF ( S0 .GT. -YTGR ) GO TO 460
C        ESTABLISH REGION 6
              S0 = -YTGR + SMALL * ( STRAIN-TEMP0 )
              E0 = SMALL
C        CHECK IF MONOTONIC EXCURSION INTO -VE STRAIN HARDENING ?
  460    IF ( YTGR .GT. SIGCOM(K) ) GO TO 467
         IF ( STRAIN .GT. -EPHD )   GO TO 467
C        FOLLOW -VE BRANCH OF VIRGIN STRAIN HARDENING
              E0 = SLHD
              S0 = -SIGCOM(K) - SMALL * ( EPHD - EPSCOM(K) )
     2                        + SLHD  * ( STRAIN + EPHD )
  467    IF ( S0 .GT. -SULT ) GO TO 470
              S0 = -SULT
              E0 = 0.0
  470         EPBFRT = STRAIN
              SLBFRT = E0
         IF ( IFAE .EQ. 1 ) GO TO 484
         IF ( K    .NE. 1 ) GO TO 484
              NRGICN(I,L,ICUMU) = -1
         GO TO 484
C        ELASTIC REGION 3 ( OR 3' )
  476         E0     = SLOPE
              S0     = SLOPE * ( STRAIN - ER )
              EPBFRT = EPBFR
              SLBFRT = SLBFR
              YTGR   = YGR
         IF ( IFAE .EQ. 1 ) GO TO 484
         IF ( K    .NE. 1 ) GO TO 484
              NRGICN(I,L,ICUMU) = 0
C        SET THE VALUE OF THE TEMPORARY RESIDUAL STRAIN .
  484         ERT = STRAIN - S0 / SLOPE
         IF ( IFAE .EQ. 1 ) GO TO 500
         IF ( K    .NE. 1 ) GO TO 500
         IF (DABS(E0-SLOPE).GT.1.0D-05) GO TO 500
              NRGICN(I,L,ICUMU) = 0
  500    CONTINUE
              STRESS = STRESS + S0
              STIFF  = STIFF  + E0
  600    CONTINUE
         IF ( K .NE. 1 )             GO TO 650
         IF ( MODEL(ISIT) .NE. 2 ) GO TO 650
              YGROW (I,L,ICUMU) = YGR
              YTGROW(I,L,ICUMU) = YTGR
  650    CONTINUE
         IF ( L .NE. 1 ) GO TO 1100
              EPR1S (I,ICUMU,K) = ER
              EPRT1S(I,ICUMU,K) = ERT
              EPBF1 (I,ICUMU,K) = EPBFR
              EPBFT1(I,ICUMU,K) = EPBFRT
              SLBF1 (I,ICUMU,K) = SLBFR
              SLBFT1(I,ICUMU,K) = SLBFRT
         GO TO 1150
 1100    CONTINUE
              EPR2S (I,ICUMU,K) = ER
              EPRT2S(I,ICUMU,K) = ERT
              EPBF2 (I,ICUMU,K) = EPBFR
              EPBFT2(I,ICUMU,K) = EPBFRT
              SLBF2 (I,ICUMU,K) = SLBFR
              SLBFT2(I,ICUMU,K) = SLBFRT
 1150    CONTINUE
 1200    CONTINUE
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```
      IF ( ITYPE .GE. 3 ) GO TO 1210
      IF ( IPAE  .EQ. 1 ) GO TO 1220
      IF ( NITF  .EQ. 2 .AND. NITERM(JJ) .EQ. 1 ) GO TO 1220
      GO TO 1250
 1210 CONTINUE
      IF ( IRDYN .EQ. 1 ) GO TO 1220
     IF(IRSTEP(JT).EQ.1.AND.NITF.EQ.1.AND.NITERM(JJ).EQ.1)GO TO 1220
      GO TO 1250
 1220 CONTINUE
      IF ( IRV(I,L,ICUMU) .EQ. 0 ) GO TO 1250
           STIFF = SLPMAX
      IF ( ITYPE .LE. 2 ) GO TO 1240
      IF ( IRDYN .EQ. 1 ) GO TO 1250
     IF(IRSTEP(JT).EQ.1.AND.NITF.EQ.1.AND.NITERM(JJ).EQ.1)
     2     IRV(I,L,ICUMU) = 0
      GO TO 1250
 1240 CONTINUE
      IF ( IPAE .EQ. 0 ) IRV(I,L,ICUMU) = 0
 1250 CONTINUE
COMMENT - STIFF = 10 * STIFF  FOR RIGID ELEMENT
      IF ( IR .EQ. 1 ) STIFF = 10.0 * STIFF
      IF ( IR .EQ. 1 .OR. IE .EQ. 1 ) GO TO 1300
      GO TO 1400
 1300 CONTINUE
           STRESS = STIFF * STRAIN
 1400 CONTINUE
           SIGHIS(L) = STRESS
           STFHIS(L) = STIFF
COMMENT - OUTPUT MESSAGE (DURING FINAL MEMBER SOLUTION ONLY) IF THE
COMMENT - STRAIN EXCEEDS THE LAST STRAIN ORDINATE OF VIRGIN CURVE.
      IF ( NITM(JJ) .NE. MNITM+2 ) GO TO 1500
      IF ( BET .LT. 1.0D-15 ) GO TO 1420
      IF ( SLHD .EQ. 0 )      GO TO 1500
           STEMP = SIGCOM(1)  + ( EPHD-EPSCOM(1) ) * SMALL
           EPULT = EPHD       + ( SULT-STEMP) / SLHD
      IF ( DABS(STRAIN) .LT. EPULT ) GO TO 1500
    PRINT 25, JJ,I,L,ICUMU,STRAIN,SIGHIS(L),STFHIS(L)
      GO TO 1500
 1420 CONTINUE
      IF (DABS(STRAIN) .LT. EPSCOM(NPTSM1) ) GO TO 1500
      IF ( NPTSM1 .EQ. 1 ) GO TO 1500
    PRINT 25, JJ,I,L,ICUMU,STRAIN,SIGHIS(L),STFHIS(L)
 1500 CONTINUE
      IF ( IR .EQ. 1 .OR. IE .EQ. 1 ) GO TO 2000
      IF ( NCHECK .NE. 1 ) GO TO 1800
           IRVRSE = IRVRSE + IRV(I,L,ICUMU)
 1800 CONTINUE
           EPSPRE(I,L,ICUMU) = STRAIN

 2000 CONTINUE
    RETURN
    END


********************************** SUBROUTINE **********************************
      SUBROUTINE MATMPY(A,M1,N1,B,N2,C)
COMMENT - SUBROUTINE MATMPY MULTIPLIES A M1XN1 MATRIX A TIMES A N1XN2
COMMENT - MATRIX B TO YIELD THE M1XN2 MATRIX C
      IMPLICIT REAL*8 (A-H,O-Z)
      DIMENSION A(6,6), B(6,6), C(6,6)
      DO 25 I = 1,M1
      DO 25 J = 1,N2
      C(I,J) = 0
      DO 25 K = 1,N1
   25 C(I,J)= A(I,K)*B(K,J)  + C(I,J)
   11 RETURN
      END


********************************** SUBROUTINE **********************************
      SUBROUTINE SANGLE (SA,SXT,SYT)
COMMENT - SANGLE COMPUTES THE STIFFNESS MATRIX FOR MEMBER SPRINGS IN
COMMENT - STRUCTURE DIRECTIONS
      IMPLICIT REAL*8 (A-H,O-Z)
      DIMENSION SA(3,3)
      COMMON /BLOCK2/ DXS( 25),    DYS( 25),    ZLS( 25),    DC1S( 25),
     2    DC2S( 25),  PRP( 25),    PRAE( 25),  QM( 25),     WM( 25),
     3    PRAG(25),   ELEMN(25),
     4    IOPOP( 25), IPINL( 25), IPINR( 25), NC51( 25),  INLOP( 25),
     5    NAL( 25),   NSXL( 25),  NSYL( 25),  NSZL( 25),  NAR( 25),
     6    NSXR( 25),  NSYR( 25),  NSZR( 25),  NCDS( 25),  IAXOPS( 25)
      COMMON /BLK1/  TOL,    ELEMNT,NJST,    KEEP3C,NCD3C,
     2          KEEP2, KEEP3A,KEEP3B,KEEP4A,KEEP4B,KEEP4C,KEEP5A,
     3          KEEP5B,KEEP5C,KEEP5D,KEEP6, KEEP7, NCD2,  NCD3A,
     4          NCD3B, NCD4A, NCD4B, NCD4C, NCD5A, NCD5B, NCD5C,
     5          NCD5D, NCD6,  NCD7,  IP8,   IP9,   IP10,  ITYPE,
     6          IABAN, IFORM, NM,    NJT,   NST,   NLT,   M,
     7          MP1,   MP2,   ISTT,  LTT,   ITYPEL,IDJ,   NSTL
           ALS = DC1S(ISTT)**2
           BES = DC2S(ISTT)**2
           ALBE = DC1S(ISTT)*DC2S(ISTT)
           SA(1,1) = ALS*SXT + BES*SYT
           SA(1,2) = ALBE*( -SXT + SYT)
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          SA (2,1) = SA (1,2)
          SA (2,2) = BES*SXI + ALS*SYT
          SA (1,3) = 0.0
          SA (2,3) = 0.0
          SA (3,1) = 0.0
          SA (3,2) = 0.0
          SA (3,3) = 0.0
      RETURN
      END


********************************** SOBROUTINE **********************************
      SUBROUTINE MEMENI (W,FMMI,L6)
COMMENT - MEMENI COMPUTES THE INCREMENTAL MEMBER-END FORCES FOR FINDING
COMMENT - INCREMENTAL FIXED-END-FCRCES AND TANGENT STIFFNESS MATRIX
      IMPLICIT REAL*8 (A-H,O-Z)
      DIMENSION W(L6)
      DIMENSION SEE3(3,3), WT(3), FMMT(3), FMMI(6),SA(3,3)
      COMMON /BLOCK2/ DXS( 25),    DYS( 25),   ZLS( 25),   DC1S( 25),
     2   DC2S( 25),   PRF( 25),    PRAE( 25),  QM( 25),    WM( 25),
     3   PRAG(25),    ELEMN(25),
     4   IOPOP( 25),  IPINL( 25),  IPINR( 25), NC51( 25),  INLOP( 25),
     5   NAL( 25),    NSXL( 25),   NSYL( 25),  NSZL( 25),  NAR( 25),
     6   NSXR( 25),   NSYR( 25),   NSZR( 25),  NCDS( 25),  IAXOPS( 25)
      COMMON /BLOCK7/ F( 22),      AE( 22),    SX( 22),    SY( 22),
     2   SZ( 22),     QX( 22),     QY( 22),    QZ( 22),    DX( 22),
     3   DY( 22),     DZ( 22),     ERX( 22),   ERY( 22),   ERZ( 22),
     4   SQX( 22),    SQY( 22),    SQZ( 22),   U1( 22),    V1( 22),
     5   W1( 22),     U2( 22),     V2( 22),    W2( 22),    DS(3,3, 22),
     6   BM1S( 22),   BM2S( 22),   TTS( 22),   AG( 22)
      COMMON /BLOC11/ SEET(6,6)
      COMMON /BLK1/  TOL,    ELEMNT,NJST,   KEEP3C,NCD3C,
     2         KEEP2, KEEP3A,KEEP3B,KEEP4A,KEEP4B,KEEP4C,KEEP5A,
     3         KEEP5B,KEEP5C,KEEP5D,KEEP6, KEEP7, NCD2,  NCD3A,
     4         NCD3B, NCD4A, NCD4B, NCD4C, NCD5A, NCD5B, NCD5C,
     5         NCD5D, NCD6,  NCD7,  IP8,   IP9,   IP10,  ITYPE,
     6         IABAN, IFORM, NM,    NJT,   NST,   NLT,   M,
     7         MP1,   MP2,   ISTT,  LTT,   ITYPEL,IDJ,   NSTL
      COMMON /BLK2/ XL,XR,X1,X2,          H,TH,HSQ,HCU,X2L,I1,I2,NQ
      COMMON /BLK4/ ST1,ST2,ST3,ST4,ST5,ST6
      COMMON /BLK5/ QT1,QT2,QT3,QT4,QT5,QT6
      COMMON /BLK7/ INLOPT,IFAE,KOFFJ,KOFFQW,KOFFSE
      COMMOM /SKT8/      SEEE(6,6)
            IAXOPT = IAXOPS(ISTT)
COMMENT - COMPUTE INCREMENTAL ELEMENT-END-FORCES ON ELEMENT NUMBER 2
COMMENT - BY OSING THE UPPER HALF OF SEEE(6,6) THAT WAS STORED IN ELEMST
COMMENT - IN THE EARLIER VERSIONS THIS WAS DONE BY A CALL TO ELEMST(2)
COMMENT - WHICH HAS NOW BEEN REMOVED
      DO 100  I = 1,3
          WT(I) = W(I)
      DO 100  J = 1,3
          SEE3 (I,J) = SEEE (I,J)
  100 CONTINUE
COMMENT - MULTIPLY ELEMENT STIFFNESS MATRIX TIMES INCREMENTS OF MEMBER
COMMENT - DISPLACEMENTS AT MEMBERS END
      CALL       MATM31 (SEE3, WT, FMMT)
      DO 150  I = 1,3
          FMMI(I) = FMMT(I)
  150 CONTINUE
      DO 200  I = 1,3
          IP3 = I + 3
          WT(I) = W(IP3)
      DO 200  J = 1,3
          JP3 = J + 3
          SEE3 (I,J) = SEEE (I,JP3)
  200 CONTINUE
COMMENT - MULTIPLY ELEMENT STIFFNESS MATRIX TIMES INCREMENTS OF MEMBER
COMMENT - DISPLACEMENTS AT FIRST STATION INSIDE MEMBERS END
      CALL       MATM31 (SEE3,WT,FMMT)
      DO 250  I = 1,3
          FMMI(I) = FMMI(I) + FMMT(I)
  250 CONTINUE
COMMENT - COMPUTE INCREMENTAL ELEMENT-END-FORCES CN ELEMENT NUMBER MP1
COMMENT - BY USING THE LOWER HALF OF SEEE(6,6) THAT WAS STORED IN ELEMST
COMMENT - IN THE EARLIER VERSIONS THIS WAS DONE BY A CALL TO ELEMST(MP1)
COMMENT - WHICH HAS NOW BEEN REMOVED
      DO 600  I = 1,3
          IP3M1 = I + 3*(M - 1)
          WT(I) = W(IP3M1)
          IP3 = I + 3
      DO 600  J = 1,3
          SEE3 (I,J) = SEEE (IP3,J)
  600 CONTINUE
COMMENT - MULTIPLY ELEMENT STIFFNESS MATRIX TIMES INCREMENTS OF MEMBER
COMMENT - DISPLACEMENTS AT MEMBERS END
      CALL       MATM31 (SEE3, WT, FMMT)
      DO 650  I = 1,3
          IP3 = I + 3
          FMMI(IP3) = FMMT(I)
  650 CONTINUE
      DO 700  I = 1,3
          IP3 = I + 3
          IP3M = I + 3*M
          WT(I) = W(IP3M)
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         DO 700  J = 1,3
              JP3 = J + 3
              SEE3 (I,J) = SEEE (IP3,JP3)
  700    CONTINUE
COMMENT - MULTIPLY ELEMENT STIFFNESS MATRIX TIMES INCREMENTS OF MEMBER
COMMENT - DISPLACEMENTS AT FIRST STATION INSIDE MEMBERS END
     CALL        MATM31 (SEE3, WT, FMMT)
         DO 750  I = 1,3
              IP3 = I + 3
              FMMI(IP3) = FMMI(IP3) + FMMT(I)
  750    CONTINUE
COMMENT - ADD ON INCREMENTAL END-LOADS AND INCREMENTAL SPRING FORCES AT
COMMENT - END STATIONS
              FMMI(3) = FMMI(3) + ST3*W(3) - QT3
              FMMI(6) = FMMI(6) + ST6*WT(3) - QT6
         IF (IAXOPT .EQ. 2) GO TO 800
              FMMI(1) = FMMI(1) + ST1*W(1) - QT1
              FMMI(2) = FMMI(2) + ST2*W(2) - QT2
              FMMI(4) = FMMI(4) + ST4*WT(1) - QT4
              FMMI(5) = FMMI(5) + ST5*WT(2) - QT5
         GO TO 900
COMMENT - MEMBER SPRINGS IN STRUCTURE DIRECTIONS
  800 CALL        SANGLE (SA,ST4,ST5)
      CALL        MATM31 (SA,WT,FMMT)
              FMMI(4) = FMMI(4) + FMMT(1) - QT4
              FMMI(5) = FMMI(5) + FMMT(2) - QT5
              WT(1) = W(1)
              WT(2) = W(2)
              WT(3) = 0.0
      CALL        SANGLE (SA,ST1,ST2)
      CALL        MATM31(SA,WT,FMMT)
              FMMI(1) = FMMI(1) + FMMT(1) - QT1
              FMMI(2) = FMMI(2) + FMMT(2) - QT2
  900    CONTINUE
      RETURN
      END


*********************************** SUBROUTINE ***********************************
      SUBROUTINE FORMLD ( RM, RO, W, SL, FOMT, L1, L3, L4, L6, JJ)
COMMENT - SUBROUTINE FORMLD CALCULATES MEMBER INCREMENTAL FIXED-END-
COMMENT - FORCE MATRIX ON FIRST ITERATION OF EACH PROBLEM
      IMPLICIT REAL*8 (A-H,O-Z)
      DIMENSION RM(L6,L4), RO(L6), W(L6)
      DIMENSION FOMT(6),WT(3),FT(3),SA(3,3)
      COMMON /BLOCK2/ DXS( 25),    DYS( 25),    ZLS( 25),    DC1S( 25),
     2     DC2S( 25),   PRF( 25),    PRAE( 25),   QM( 25),     WM( 25),
     3     PRAG(25),    ELEMN(25),
     4     IOPOP( 25),  IPINL( 25),  IPINR( 25),  NC51( 25),   INLOP( 25),
     5     NAL( 25),    NSXL( 25),   NSYL( 25),   NSZL( 25),   NAR( 25),
     6     NSXR( 25),   NSYR( 25),   NSZR( 25),   NCDS( 25),   IAXOPS( 25)
      COMMON /BLOCK3/ DXL( 25),    DYL( 25),    ZLL( 25),    DC1L( 25),
     2     DC2L( 25),   UQX( 25),    UQY( 25),    NCDL( 25),   IAXOPL( 25),
     3     NC61( 25),   ICVBM(25)
      COMMON /BLOCK4/ FOMM(50,6),SMC(50,21),IST(50),   LT(50),
     2     JT1(50),     JT2(50),     NITM(50),    IMM(50),     IMC(50)
      COMMON /BLOCK5/ XLS( 50),    XRS( 50),    FL( 50),     AEL( 50),
     2     SXL( 50),    SYL( 50),    SZL( 50)
      COMMON /BLOCK6/ XLL( 75),    XRL( 75),    QXL( 75),    QYL( 75),
     2     QZL( 75),    IOVRL(75)
      COMMON /BLOCK7/ F( 22),      AE( 22),     SX( 22),     SY( 22),
     2     SZ( 22),     QX( 22),     QY( 22),     QZ( 22),     DX( 22),
     3     DY( 22),     DZ( 22),     ERX( 22),    ERY( 22),    ERZ( 22),
     4     SQX( 22),    SQY( 22),    SQZ( 22),    U1( 22),     V1( 22),
     5     W1( 22),     U2( 22),     V2( 22),     W2( 22),     DS(3,3, 22),
     6     BM1S( 22),   BM2S( 22),   TTS( 22),    AG( 22)
      COMMON /BLK1/  TOL,    ELEMNT,NJST,   KEEP3C,NCD3C,
     2          KEEP2, KEEP3A,KEEP3B,KEEP4A,KEEP4B,KEEP4C,KEEP5A,
     3          KEEP5B,KEEP5C,KEEP5D,KEEP6, KEEP7, NCD2,  NCD3A,
     4          NCD3B, NCD4A, NCD4B, NCD4C, NCD5A, NCD5B, NCD5C,
     5          NCD5D, NCD6,  NCD7,  IP8,   IP9,   IP10,  ITYPE,
     6          IABAN, IFORM, NM,    NJT,   NST,   NLT,   M,
     7          MP1,   MP2,   ISTT,  LTT,   ITYPEL,IDJ,   NSTL
      COMMON /BLK2/ XL,XR,X1,X2,      H,TH,HSQ,HCU,X2L,I1,I2,NQ
      COMMON /BLK3/ MNJT,MNST,MNLT,MNM,MNC5,MNC6,MDJT,MNJS,MNE,MNCS,
     2     MNPCS,MNSS,MNQWM,MNJST,MNJSS
      COMMON /BLK4/ ST1,ST2,ST3,ST4,ST5,ST6
      COMMON /BLK6/ QT1,QT2,QT3,QT4,QT5,QT6
      COMMON /BLK7/ INLOPT,IFAE,KCFFJ,KOFFQW,KOPFSE
      COMMON / RI / NL, ML, J1
      COMMON /SKT7/       U1TT(21),      V1TT(21),      W1TT(21),
     2                    U2TT(21),      V2TT(21),      W2TT(21)
      COMMON /SKT14 / IRV(21,2,10),                     FOMOLD(50,6),
     2               IRVRSE,        ITAPE,              N3
           IAXOPT = IAXOPS(ISTT)
         IF (ITYPE .EQ. 1) GO TO 2400
         IF ( IRVRSE .NE. 0 ) GO TO 2200
COMMENT - STORE MEMBER-END FORCES OF LAST LOAD STEP FOR STRAIN REVERSAL
COMMENT - CHECK PURPOSES
         DO 2000 I = 1 , 6
              FOMOLD (JJ,I) = FOMM (JJ,I)
 2000    CONTINUE
COMMENT - STORE EXISTING MEMBER-ENDFORCES AS MEMBER-END-LOADS
              QT1 = FOMM(JJ,1)
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              QT2 = FOMM(JJ,2)
              QT3 = FOMM(JJ,3)
              QT4 = FOMM(JJ,4)
              QT5 = FOMM(JJ,5)
              QT6 = FOMM(JJ,6)
        GO TO 2400
 2200   CONTINUE
              QT1 = FOMOLD  ( JJ,1)
              QT2 = FOMOLD  ( JJ,2)
              QT3 = FOMOLD  ( JJ,3)
              QT4 = FOMOLD  ( JJ,4)
              QT5 = FOMOLD  ( JJ,5)
              QT6 = FOMOLD  ( JJ,6)
 2400   CONTINUE
        IF (LTT .GT. 0) GO TO 2500
COMMENT - ZERO LOADS FOR LOAD TYPE ZERO * NOTE* FIXED-END-FORCE-MATRIX
COMMENT - CALCULATED FOR MEMBER WITH NO LOADS FOR PRESTRESSING OR
COMMENT - TEMPERATURE EFFECTS AND CASE WHERE LOADS ARE REMOVED
        DO 2450  I = 1,MP1
              QX(I) = 0.0
              QY(I) = 0.0
 2450         QZ(I) = 0.0
        GO TO 3000
 2500   CONTINUE
COMMENT - SET TEMPORARY CONTROL CONSTANTS FOR LOAD TYPE WHICH IS
COMMENT - HAVING ITS FIXED-END-FORCE MATRIX FORMED
              NCDLT = NCDL(LTT)
              NC61T = NC61(LTT)
        IF (NCDLT .NE. 0) GO TO 2900
COMMENT - DISCRETIZE UNIFORM MEMBER LOADS
              UQXT = UQX(LTT)
              UQYT = UQY(LTT)
        DO 2800  I = 2,M
              QX(I) = UQXT*TH
              QY(I) = UQYT*TH
 2800         QZ(I) = 0.0
              QX(1) = 0.5*UQXT*TH
              QY(1) = 0.5*UQYT*TH
              QZ(1) = 0.0
              QX(MP1) = 0.5*UQXT*TH
              QY(MP1) = 0.5*UQYT*TH
              QZ(MP1) = 0.0
              QX(MP2) = 0.0
              QY(MP2) = 0.0
              QZ(MP2) = 0.0
        GO TO 3000
COMMENT - NONUNIFORM LOADS
COMMENT - SUBROUTINE DISCLD DISCRETIZES GENERAL MEMBER LOADS QX, QY, QZ
 2900 CALL       DISCLD ( NC61T, NCDLT, ZL, L1 )
 3000   CONTINUE
COMMENT - DO FOR EACH ELEMENT
        DO 3400  I = 2,MP1
              IM1 = I - 1
COMMENT - USE THE VALUES OF ELEMENT-END-FORCES STORED IN  ELEMST
COMMENT - EARLIER THIS WAS DONE BY A CALL TO  ELEMFO  WHICH HAS BEEN
COMMENT - NOW REMOVED
              U1T = U1TT  (I)
              V1T = V1TT  (I)
              W1T = W1TT  (I)
              U2T = U2TT  (I)
              V2T = V2TT  (I)
              W2T = W2TT  (I)
COMMENT - START COMPUTATION FOR STATION EQUILIBRIUM ERRORS BY ADDING
COMMENT - ADJACENT ELEMENT-END-FORCES AT STATIONS
              ERX(IM1) = ERX(IM1)  + U1T
              ERY(IM1) = ERY(IM1)  + V1T
              ERZ(IM1) = ERZ(IM1)  + W1T
              ERX(I) = ERX(I)  + U2T
              ERY(I) = ERY(I)  + V2T
              ERZ(I) = ERZ(I)  + W2T
 3400   CONTINUE
COMMENT - COMPLETE CALCULATIONS BY ADDING IN LOADS AND SPRING FORCES
COMMENT - DO FOR EACH INTERIOR STATION
        DO 3800  I = 2,M
        IF (INLOPT .EQ. 0)  SQZ(I) = -SZ(I)*DZ(I)
              ERZ(I) = QZ(I) - ERZ(I) + SQZ(I)
        IF (IAXOPT .EQ. 2)  GO TO 3650
        IF (INLOPT .EQ. 0)  SQX(I) = -SX(I)*DX(I)
              ERX(I) = QX(I) - ERX(I) + SQX(I)
        IF (INLOPT .EQ. 0)  SQY(I) = -SY(I)*DY(I)
              ERY(I) = QY(I) - ERY(I) + SQY(I)
        GO TO 3800
 3650   CONTINUE
COMMENT - TRANSFORM SPRING FORCES AND STIFFNESSES IF SPECIFIED IN
COMMENT - STRUCTURE DIRECTIONS
              SXT = SX(I)
              SYT = SY(I)
      CALL    SANGLE (SA,SXT,SYT)
              WT(1) = DX(I)
              WT(2) = DY(I)
              WT(3) = 0.0
      CALL    MATM31 (SA,WT , FT)
        IF (INLOPT .EQ. 0)  SQX(I) = -FT(1)
              ERX(I) = QX(I) - ERX(I) + SQX(I)
        IF (INLOPT .EQ. 0)  SQY(I) = - FT(2)
              ERY(I) = QY(I) - ERY(I) + SQY(I)
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 3800     CONTINUE
COMMENT - DO FOR END STATIONS
          IF (INLOPT .EQ. 0) SQZ(1) = -ST3*DZ(1)
              ERZ(1) = QZ(1) - ERZ(1) + SQZ(1)
          IF (INLOPT .EQ. 0) SQZ(MP1) = -ST6*DZ(MP1)
              ERZ(MP1) = QZ(MP1) - ERZ(MP1) +SQZ(MP1)
         IF (IAXOPT .EQ. 2) GO TO 3900
          IF (INLOPT .EQ. 0) SQX(1) = -ST1*DX(1)
              ERX(1) = QX(1) - ERX(1) + SQX(1)
          IF (INLOPT .EQ. 0) SQY(1) = -ST2*DY(1)
              ERY(1) = QY(1) - ERY(1) +SQY(1)
          IF (INLOPT .EQ. 0) SQX(MP1) = -ST4*DX(MP1)
              ERX(MP1) = QX(MP1) - ERX(MP1) +SQX(MP1)
          IF (INLOPT .EQ. 0) SQY(MP1) = -ST5*DY(MP1)
              ERY(MP1) = QY(MP1) - ERY(MP1) +SQY(MP1)
          GO TO 4100
 3900     CONTINUE
COMMENT - TRANSFORM SPRING FORCES AND STIFFNESSES IF SPECIFIED IN
COMMENT - STRUCTURE DIRECTIONS
      CALL        SANGLE (SA,ST1,ST2)
              WT(1) = DX(1)
              WT(2) = DY(1)
              WT(3) = 0.0
      CALL        MATM31 (SA,WT,FT)
          IF (INLOPT .EQ. 0) SQX(1) = -FT(1)
              ERX(1) = QX(1) - ERX(1) + SQX(1)
          IF (INLOPT .EQ. 0) SQY(1) = -FT(2)
              ERY(1) = QY(1) - ERY(1) + SQY(1)
      CALL        SANGLE (SA,ST4,ST5)
              WT(1) = DX(MP1)
              WT(2) = DY(MP1)
      CALL        MATM31 (SA,WT,FT)
          IF (INLOPT .EQ. 0) SQX(MP1) = -FT(1)
              ERX(MP1) = QX(MP1) - ERX(MP1) + SQX(MP1)
          IF (INLOPT .EQ. 0) SQY(MP1) = -FT(2)
              ERY(MP1) = QY(MP1) - ERY(MP1) + SQY(MP1)
 4100     CONTINUE
              QT1 = QT1 + ERX(1)
              QT2 = QT2 + ERY(1)
              QT3 = QT3 + ERZ(1)
              QT4 = QT4 + ERX(MP1)
              QT5 = QT5 + ERY(MP1)
              QT6 = QT6 + ERZ(MP1)
COMMENT - CALL GRIP2A FOR SOLUTION OF MEMBER INCREMENTAL LOADS (STATION
COMMENT - EQUILIBRIUM ERRORS)
      CALL        GRIP2A ( RM,EO,W,SL,L3,L4,L6,5)
COMMENT - CALL MEMENI FOR CACULATION OF INCREMENTAL FIXED-END-FORCES
      CALL        MEMENI ( W,FOMT,L6 )
 9900     CONTINUE
      RETURN
      END


*********************************** SUBROUTINE ***********************************
      SUBROUTINE DISCLD ( NC61T, NCDLT, ZL, L1 )
COMMENT - SUBROUTINE DISCLD COMPUTES EQUIVALENT MEMBER STATION LOADS FOR
COMMENT - CONCENTRATED AND DISTRIBUTED LOADS OVER A MEMBER.
      IMPLICIT REAL*8 (A-H,O-Z)
      COMMON /BLOCK6/ XLL( 75),   XRL( 75),   QXL( 75),   QYL( 75),
     2   QZL( 75),   IOVEL(75)
      COMMON /BLOCK7/ F( 22),     AE( 22),    SX( 22),    SY( 22),
     2   SZ( 22),    QX( 22),    QY( 22),    QZ( 22),    DX( 22),
     3   DY( 22),    DZ( 22),    ERX( 22),   ERY( 22),   ERZ( 22),
     4   SQX( 22),   SQY( 22),   SQZ( 22),   U1( 22),    V1( 22),
     5   W1( 22),    U2( 22),    V2( 22),    W2( 22),    DS(3,3, 22),
     6   BM1S( 22),  BM2S( 22),  TTS( 22),   AG( 22)
      COMMON /BLK1/  TOL,    ELEMNT,NJST,  KEEP3C,NCD3C,
     2        KEEP2, KEEP3A,KEEP3B,KEEP4A,KEEP4B,KEEP4C,KEEP5A,
     3        KEEP5B,KEEP5C,KEEP5D,KEEP6, KEEP7,  NCD2,  NCD3A,
     4        NCD3B, NCD4A, NCD4B, NCD4C, NCD5A, NCD5B, NCD5C,
     5        NCD5D, NCD6,  NCD7,  IP8,   IP9,   IP10,  ITYPE,
     6        IABAN, IFCRE, NM,    NJT,   NST,   NLT,   M,
     7        MP1,   MP2,   ISIT,  LTT,   ITYPEL,IDJ,   NSTL
      COMMON /BLK2/ XL,XR,X1,X2,         H,TH,HSQ,HCU,X2L,I1,I2,NQ
COMMENT - ZERO MEMBER LOAD DATA
          DO 1020  I = 1,MP2
              QX(I) = 0.0
              QY(I) = 0.0
 1020         QZ(I) = 0.0
              NC62T = NC61T - 1 + NCDLT
              II = NC61T - 1
COMMENT - II GOES FROM NC61T TO NC62T
 1050         II = II + 1
COMMENT - READ DATA FROM ONE CARD IMAGE (LOADS AT LEFT OF SECTION)
              XL = XLL(II)
              XR = XRL(II)
              QXLT = QXL(II)
              QYLT = QYL(II)
              QZLT = QZL(II)
          IF (XR .NE. 0.0) GO TO 1100
COMMENT - VARIABLE LOADING SECTION READ ONE CARD IMAGE (LOADS AT
COMMENT - RIGHT OF SECTION)
              II = II + 1
              XR = XRL(II)
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                QXRT = QXL(II)
                QYRT = QYL(II)
                QZRT = QZL(II)
          GO TO 1110
 1100           QXRT = QXLT
                QYRT = QYLT
                QZRT = QZLT
 1110     CONTINUE
          IF ( XL .NE. XR) GO TO 2100
COMMENT - CONCENTRATED LOADS CALL CONLD TO DISTRIBUTE CONCENTRATED
COMMENT - LOADS TO ADJACENT STATIONS
      CALL       CONLD ( QXLT, XL, QX, L1 )
      CALL       CONLD ( QYLT, XL, QY, L1 )
      CALL       CONLD ( QZLT, XL, QZ, L1 )
          GO TO 2200
 2100     CONTINUE
                ZI1 = XL/TH + 2.0
                I1 = ZI1
                X1 = I1*TH - XL - TH
                ZI2 = XR/TH + 1.0
                I2 = ZI2
                X2 = XR - I2*TH + TH
                NQ = I2 - I1
COMMENT - DISTRIBUTION LOADS CALL LINLD TO DISTRIBUTE LOADS STATIONS
COMMENT - I1 TO I2
          IF (QXLT .EQ. 0.0 .AND. QXRT .EQ. 0.0) GO TO 2150
      CALL       LINLD ( QXLT, QXRT, QX, L1 )
 2150     IF (QYLT .EQ. 0.0 .AND. QYRT .EQ. 0.0) GO TO 2160
      CALL       LINLD ( QYLT, QYRT, QY, L1 )
 2160     IF (QZLT .EQ. 0.0 .AND. QZRT .EQ. 0.0) GO TO 2200
      CALL       LINLD ( QZLT, QZRT, QZ, L1 )
 2200     CONTINUE
 9000     IF (II .LT. NC62T) GO TO 1050
 9900     CONTINUE
      RETURN
      END


********************************** SUBROUTINE **********************************
      SUBROUTINE MEMSOL (     RM,RC,W,SL,L1,L3,L4,L6)
COMMENT - SUBROUTINE MEMSOL DOES THE ITERATIVE NONLINEAR MEMBER SOLUTION
COMMENT - THIS SOLUTICN IS REQUIRED TO FIND THE MEMBER-END-FORCES FOR
COMMENT - THE JOINT EQUILIBRIUM CHECK AND FOR THE FINAL MEMBER SCLUTION
      IMPLICIT REAL*8 (A-H,O-Z)
      REAL*8 JTSHR,JSYES
      REAL*8 MEMBER

      REAL*4 DISJT
      DIMENSION RM(L6,L4), RO(L6), W(L6)
      DIMENSION DC(3,3), DMM(3), SA(3,3),  DMS(3), FMM(6), FMT(3)
      DIMENSION TRD(4,4),DMS4(4)
      DIMENSION ALPHA(41)
      COMMON /BLOCK1/ X(25),        Y(25),       QXX(25),     QYY(25),
     2     QZZ(25),     SXX(25),      SYY(25),     SZZ(25),     DXX(25),
     3     DYY(25),     DZZ(25),      RXX(25),     RYY(25),     RZZ(25),
     4     ERXX(25),    ERYY(25),     ERZZ(25),    QMJ(25),     WMJ(25),
     5     NSXX(25),    NSYY(25),     NSZZ(25),    IMJ(25),     NSXP(25),
     6     NSYP(25),    ISTJR(25)
      COMMON /BALA01/ QVV(25),      SVV(25),     DVV(25),     ERVV(25),
     2     RVV(25),     NSVV(25)
      COMMON /BLOCK2/ DXS( 25),     DYS( 25),    ZLS( 25),    DC1S( 25),
     2     DC2S( 25),   PRF( 25),     PRAE( 25),   QM( 25),     WM( 25),
     3     PRAG(25),    ELEMN(25),
     4     IOPOP( 25),  IPINL( 25),   IPINR( 25),  NC51( 25),   INLOP( 25),
     5     NAL( 25),    NSXL( 25),    NSYL( 25),   NSZL( 25),   NAR( 25),
     6     NSXR( 25),   NSYR( 25),    NSZR( 25),   NCDS( 25),   IAXOPS( 25)
      COMMON /BALA02/ JST(25),NJSS(25),HLJ(25),HRJ(25),VLJ(25),VUJ(25),
     2     THKJ(25),GJ(25),SJC(25)
      COMMON /BLOCK3/ DXL( 25),     DYL( 25),    ZLL( 25),    DC1L( 25),
     2     DC2L( 25),   UQX( 25),     UQY( 25),    NCDL( 25),   IAXCPL( 25),
     3     NC61( 25),   IOVRM(25)
      COMMON /BLOCK4/ FOMM(50,6),SMC(50,21),IST(50),    LT(50),
     2     JT1(50),     JT2(50),        NITM(50),    IMM(50),     IMC(50)
      COMMON /BLOCK5/ XLS( 50),     XRS( 50),    PL( 50),     AEL( 50),
     2     SXL( 50),    SYL( 50),     SZL( 50)
      COMMON /BLOCK6/ XLL( 75),     XRL( 75),    QXL( 75),    QYL( 75),
     2     QZL( 75),    IOVRL(75)
      COMMON /BLOCK7/ F( 22),       AE( 22),     SX( 22),     SY( 22),
     2     SZ( 22),     QX( 22),      QY( 22),     QZ( 22),     DX( 22),
     3     DY( 22),     DZ( 22),      ERX( 22),    ERY( 22),    ERZ( 22),
     4     SQX( 22),    SQY( 22),     SQZ( 22),    U1( 22),     V1( 22),
     5     W1( 22),     U2( 22),      V2( 22),     W2( 22),     DS(3,3, 22),
     6     BM1S( 22),   BM2S( 22),    TTS( 22),    AG( 22)
      COMMON /BLOC12/ SM(20,10),    EM(20,10),   BI(20,10),   DI(20,10),
     2     YI(20,10),   NSS(20,10),   NA(20),      NCDA(20),    IRECT(20,10)
      COMMON /BLOC13/ NPTS( 08),     ISS( 08),   NSIG(08,11),NEPS(08,11),
     2     NSIT(11),    NEPT(11)
      COMMON /BLOC21/ ACCJT(100),VELJT(100),ZMASSR(100),DACCJT(100),
     2     DVELJT(100),FACCJT(100),FDAMJT(100),CDAMP(100),DISJT(80,71)
      COMMON /BLK1/   TOL,     ELEMN1,NJST,   KEEP3C,NCD3C,
     2           KEEP2,  KEEP3A,KEEP3E,KEEP4A,KEEP4B,KEEP4C,KEEP5A,
     3           KEEP5B,KEEP5C,KEEP5D,KEEP6,  KEEP7,  NCD2,   NCD3A,
     4           NCD3B,  NCD4A,  NCD4B,  NCD4C,  NCD5A,  NCD5B,  NCD5C,
     5           NCD5D,  NCD6,   NCD7,   IP8,    IP9,    IP10,   ITYPE,
     6           IABAN,  IFORM,  NM,     NJT,    NST,    NLT,    M,
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7              MP1,     MP2,     ISTT,    LTT,     ITYPEL,IDJ,     NSTL
 COMMON /BLK2/  XL,XR,X1,X2,                   H,TH,HSQ,HCU,X2L,I1,I2,NQ
 COMMON /BLK3/  MNJT,MNST,MNLT,MNM,MNC5,MNC6,MDJT,MNJS,MNE,MNCS,
2     MNPCS,MNSS,MNQWM,MNJST,MNJSS
 COMMON /BLK4/  ST1,ST2,ST3,ST4,ST5,ST6
 COMMON /BLK5/  NFSUB,NITF,N1,N2
 COMMON /BLK6/  QT1,QT2,QT3,QT4,QT5,QT6
 COMMON /BLK7/  INLOPT,IFAE,KOFFJ,KOFFQW,KOFFSE
 COMMON /  RI  /  NL,  ML,  J1
 COMMON/ITC/  ERR1,ERR2,ER1,ER2,DTI,CM,NTI,MM(20),MJ(20),MNITF,
2             MNITM,NSMJ,NSMM
 COMMON /NIT/  APROB
 COMMON /SKT2/       WRX(25,10),  WRY(25,10),  WRZ(25,10),
2     WRV(25,10),  WRXP(25,10), WRYP(25,10), WRTX(25,10),
3     WRTY(25,10), WRTZ(25,10), WRTV(25,10), WRTXP(25,10),
4     WRTYP(25,10)
 COMMON /SKT5/          WRXM (21,10),  WRYM (21,10),  WRZM (21,10),
2                       WRTXM(21,10),  WRTYM(21,10),  WRTZM(21,10)
 COMMON /SKT6/          NITERM(50), INDEX
 COMMON /SKT9/          ENDFOR(50,6)
 COMMON /SKT10/         NDIV(20,10),    NPCTOT(20)
 COMMON /SKT11/         MSSINL,         MSSIM1
 COMMON /SKT13/         EPR1S(21,10,3),EPRT1S(21,10,3),
2                       EPR2S(21,10,3),EPRT2S(21,10,3)
 COMMON /SKT14 / IRV(21,2,10),                       FOMOLD(50,6),
2                IRVRSE,          ITAPE,             N3
 COMMON /SKT15/  JJ
 COMMON /SKT17/  N4
 COMMON /SKT18/  NCHECK
 COMMON /SKT20/  MCRGON(21,3), MCUREV(21,3)
 COMMON /SKT22/  TIME, JT, IRDYN, IRSTEP(71)
 COMMON /SKT27/  IREAD, IWRITE
 COMMON /SKT30/  MSTIP(25), MLOAD(25), MODEL(25)
 COMMON /SKT32/  EPBF1  (21,10,3), EPBFT1(21,10,3), SLBF1 (21,10,3),
2                SLBFT1(21,10,3), EPBF2  (21,10,3), EPBFT2(21,10,3),
3                SLBF2  (21,10,3), SLBFT2(21,10,3),
4                EPSMAX(21,2,10), EPSMIN(21,2,10), EPSPRE(21,2,10),
5                YGROW  (21,2,10), YTGROW(21,2,10)
 COMMON /CHAN1/  JTSHR
      DATA PRINT /4HRINT/
            DATA A,B,C /1H ,1H*,1H-/
            DATA MEMBER /4HMBER/
            DATA SHEAR /5HSHEAR/
            DATA JSYES /5HJSYES/
 40 FORMAT (89X,8(5HIXXXX),1HI,//)
 45 FORMAT ( 17X, 6 (1PE11.3), 6X, 41A1 )
 51 FORMAT (/,5X,2I5,/,15H       FROM JOINT,2X,6E11.3,/,
   2             15H      CENTERLINE,2X,6E11.3,/,
   3             15H       TO JOINT ,2X,6E11.3)
 52 FORMAT   (88X,6HMEMBER,I5,26H CONVERGED AFTER ITERATION,I5)
 53 FORMAT (//,11H        MEMBER,I5,  30H NOT CONVERGED AFTER ITERATION,
   2   I5,//)
 54 FORMAT (     46H        ** LIMIT OF MEMBERS Q-W CURVE EXCEEDED ON,
   2             24H PRECEEDING ITERATION **)
 55 FORMAT (     44H        ** LIMIT OF MEMBERS STRESS-STRAIN CURVE,
   2             33H EXCEEDED ON PRECEEDING ITERATION)
COMMENT - IRDYN = 1         DENOTES THAT THE PARTICULAR TIME STEP BEING
C         EXECUTED NOW HAS ALREADY BEEN COMPLETLY SOLVED ONCE , BUT IS
C         ACCESSED  AGAIN THIS TIME ONLY FOR THE PURPOSE OF
C         (BACKED UP) STIFFNESS FORMATICN AND MEMBER-END-FORCES COMPUTE
          IF ( ITYPE .LE. 2 ) IRDYN = 0
COMMENT - SET TEMPORARY CCNTRCL CONSTANTS
             ISTT = IST(JJ)
             LTT = LT(JJ)
          IF ( ISTT .EQ. 0 ) GO TC 9900
             M = MSTIF (ISTT)
            MP1= M+1
            MP2= M+2
             MP22 = MP2/2
             IAXOPT = IAXOPS(ISTT)
             IPINLT = IPINL(ISTT)
             IPINRT = IPINR(ISTT)
             ZL = ZLS(ISTT)
             NCDST = NCDS(ISTT)
             NC51T = NC51(ISTT)
             INLOPT = INLOP(ISTT)
             MODELT = MCDEL(ISTT)
             ELEMNT = ELEMN(ISTT)
             TH = ZL/M
             H = 0.5*TH
             HSQ = H*H
             HCU = HSQ*H
             NL = 3*MP1
             ML = 1
             NFSUB = 22
          IF ( INLOPT .EQ. 0 ) GO TO 2000
             NHINGE = 2
          IF (ELEMNT .EQ. SHEAR) NHINGE=1
             NALT   = NAL(ISTT)
             NCDAT  = NCDA(ISTT)
             NWRITE = NSXL(ISTT)+NSYL(ISTT)+NSZL(ISTT)
 2000     CONTINUE
          IF (ELEMNT .EQ. SHEAR) GO TC 23010
          IF (INLOPT .EQ. 1) GO TC 25C0
          IF (NCDST .EQ. 0) GO TC 2100
COMMENT - NONPRISMATIC MEMBER DISCRETIZE MEMBER STIFFNESS DATA
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      CALL  DISCST (NC51T,NCDST,ZL,L1)
            GO TO 2400
 2100       CONTINUE
COMMENT - PRISMATIC MEMBER DISCRETIZE MEMBER STIFFNESS DATA
                 PRFT = PRF(ISTT)
                 PRAET = PRAE(ISTT)
            DO 2300  I = 1,MP2
                 SX(I) = 0.0
                 SY(I) = 0.0
                 SZ(I) = 0.0
                 SQX(I) = 0.0
                 SQY(I) = 0.0
                 SQZ(I) = 0.0
                 AE(I) = PRAET
 2300            F(I) = PRFT
                 AE(1) = 0.0
                 F(1) = 0.0
                 AE(MP2) = 0.0
                 F(MP2) = 0.0
            GO TO 2400
COMMENT - PRISMATIC MEMBER DISCRETIZE MEMBER STIFFNESS DATA FOR A
COMMENT - SHEAR MODEL
 23010      CONTINUE
            IF (INLOPT .EQ. 1) GO TO 2500
                 PRFT = PRF(ISTT)
                 PRAET = PRAE(ISTT)
                 PRAGT = PRAG(ISTT)
            DO 23030 I = 1,MP2
                 SX(I) = 0.0
                 SY(I) = 0.0
                 SZ(I) = 0.0
                 SQX(I) = 0.0
                 SQY(I) = 0.0
                 SQZ(I) = 0.0
                 AE(I) = PRAET
                 F(I) = PRFT
 23030           AG(I) = PRAGT
                 AE(1) = 0.0
                 F(1) = 0.0
                 AG(1) = 0.0
                 AE(MP2) = 0.0
                 F(MP2) = 0.0
                 AG(MP2) = 0.0
 2400       CONTINUE
COMMENT - STORE MEMBER - END - RESTRAINTS (LINEAR SPRINGS)
                 ST1 = SX(1)
                 ST2 = SY(1)
                 ST3 = SZ(1)

                 ST4 = SX(MP1)
                 ST5 = SY(MP1)
                 ST6 = SZ(MP1)
 2500       CONTINUE
            IF ( IRDYN .EQ. 1 ) GO TO 2700
            IF (NITM(JJ) .EQ. MNITM + 1) GO TO 2700
COMMENT - SKIP FOR FINAL MEMBER SOLUTION
COMMENT - SET UP MEMBERS TRANSFORMATION MATRIX DC
                 DC(1,3) = 0.0
                 DC(2,3) = 0.0
                 DC(3,1) = 0.0
                 DC(3,2) = 0.0
                 DC(3,3) = 1.0
                 DC(1,1) = DC1S(ISTT)
                 DC(1,2) = DC2S(ISTT)
                 DC(2,1) = -DC(1,2)
                 DC(2,2) = DC(1,1)
 2700       CONTINUE
            IF (LTT .NE. 0 ) GO TO 2750
COMMENT - ZERO MEMBER LOADS FOR LOAD TYPE ZERO
            DO 2720  I = 1,MP2
                 QX(I) = 0.0
                 QY(I) = 0.0
 2720            QZ(I) = 0.0
            GO TO 3000
COMMENT - SET CONTROL CONSTANTS
 2750       CONTINUE
                 NCDLT = NCDL(LTT)
                 NC61T = NC61(LTT)
            IF (NCDLT .NE. 0) GO TO 2900
COMMENT - UNIFORMLY LOADED MEMBER DISCRETIZE MEMBER LOADS
                 UQXT = UQX(LTT)
                 UQYT = UQY(LTT)
            DO 2800  I = 2,M
                 QX(I) = UQXT*TH
                 QY(I) = UQYT*TH
 2800            QZ(I) = 0.0
                 QX(1) = 0.5*UQXT*TH
                 QY(1) = 0.5*UQYT*TH
                 QZ(1) = 0.0
                 QX(MP1) = 0.5*UQXT*TH
                 QY(MP1) = 0.5*UQYT*TH
                 QZ(MP1) = 0.0
                 QX(MP2) = 0.0
                 QY(MP2) = 0.0
                 QZ(MP2) = 0.0
            GO TO 3000
COMMENT - DISCRETIZE GENERAL MEMBER LOADS
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 2900 CALL      DISCLD ( NC61T, NCDLT, ZL , L1 )
 3000      CONTINUE
COMMENT - STORE MEMBER-END-LOADS QT1 -QT6
               QT1 = QX(1)
               QT2 = QY(1)
               QT3 = QZ(1)
               QT4 = QX(MP1)
               QT5 = QY(MP1)
               QT6 = QZ(MP1)
               NITERM (JJ) = 1
          IF ( ITYPE .GE. 3 ) GO TO 3076
          IF (NITF .GT. 1) GO TO 3080
          IF (ITYPE.EQ.2)GO TO 3080
COMMENT - SKIP FOR FINAL MEMBER SOLUTION
          IF (NITM(JJ) .EQ. MNITM + 1) GO TO 3080
          DO 3050  I = 1,MP2
               DX(I) = 0.0
               DY(I) = 0.0
 3050          DZ(I) = 0.0
          IF ( INLOPT .EQ. 0 ) GO TO 3100
          IF ( NWRITE .EQ. 0 ) GO TO 3055
          DO 3052 I = 2,MP1
          DO 3052 J = 1,10
               WRXM (I,J) = 0.0
               WRTXM(I,J) = 0.0
               WRYM (I,J) = 0.0
               WRTYM(I,J) = 0.0
               WRZM (I,J) = 0.0
               WRTZM(I,J) = 0.0
 3052     CONTINUE
          DO 3054 I = 2,MP1
          DO 3054 N = 1,3
               MCUREV(I,N) = 0
 3054     CONTINUE
 3055     CONTINUE
          IF ( MODELT .LE. -1 ) GO TO 3100
          IF (ELEMNT .EQ. SHEAR) GO TO 30551
          DO 3056 I = 2,MP1
          DO 3056 J = 1,MNPCS
          DO 3056 K = 1,MSSIM1
               EPR1S (I,J,K) = 0.0
               EPRT1S(I,J,K) = 0.0
               EPR2S (I,J,K) = 0.0
               EPRT2S(I,J,K) = 0.0
 3056     CONTINUE
          IF ( MODELT .EQ. 0 ) GO TO 3071
          DO 3058 I = 2,MP1
          DO 3058 J = 1,MNPCS
          DO 3058 K = 1,MSSIM1
               EPBF1 (I,J,K) = 0.0
               EPBFT1(I,J,K) = 0.0
               SLBF1 (I,J,K) = 0.0
               SLBFT1(I,J,K) = 0.0
               EPBF2 (I,J,K) = 0.0
               EPBFT2(I,J,K) = 0.0
               SLBF2 (I,J,K) = 0.0
               SLBFT2(I,J,K) = 0.0
 3058     CONTINUE
          GO TO 3059
30551     CONTINUE
          DO 30561 I = 2,MP1
          DO 30561 J = 1,MNPCS
          DO 30561 K = 1,MSSIM1
               EPR1S (I,J,K) = 0.0
               EPRT1S(I,J,K) = 0.0
30561     CONTINUE
          IF ( MODELT .EQ. 0 ) GO TO 3071
          DO 30581 I = 2,MP1
          DO 30581 J = 1,MNPCS
          DO 30581 K = 1,MSSIM1
               EPBF1 (I,J,K) = 0.0
               EPBFT1(I,J,K) = 0.0
               SLBF1 (I,J,K) = 0.0
               SLBFT1(I,J,K) = 0.0
30581     CONTINUE
 3059     CONTINUE
          DO 3070 I = 2,MP1
          DO 3070 L = 1,NHINGE
               ICUMU = 0
          DO 3065 J = 1,NCDAT
               NSSLT  = NSS (NALT,J)
               NDIVT  = NDIV(NALT,J)
               SIGMA  = NSIG(NSSLT,2) * SM(NALT,J)
               PSLON  = NEPS(NSSLT,2) * EM(NALT,J)
          DO 3060 IDVT = 1,NDIVT
               ICUMU  = ICUMU + 1
               EPSMAX(I,L,ICUMU) =  PSLON
               EPSMIN(I,L,ICUMU) = -PSLON
               EPSPRE(I,L,ICUMU) =   0.0
          IF ( MODELT .NE. 2 ) GO TO 3060
               YGROW (I,L,ICUMU) = SIGMA
               YTGROW(I,L,ICUMU) = SIGMA
 3060     CONTINUE
 3065     CONTINUE
          IF ( ICUMU .GE. MNPCS ) GO TO 3070
               IBEGIN = ICUMU + 1
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          DO 3067 ICUMU = IBEGIN,MNPCS
                EPSMAX(I,L,ICUMU) =  PSLON
                EPSMIN(I,L,ICUMU) = -PSLON
                EPSPRE(I,L,ICUMU) =  0.0
          IF ( MODELT .NE. 2 ) GO TO 3067
                YGROW  (I,L,ICUMU) = SIGMA
                YTGROW (I,L,ICUMU) = SIGMA
 3067     CONTINUE
 3070     CONTINUE
 3071     CONTINUE
          DO 3072 I = 2,MP1
          DO 3072 L = 1,NHINGE
          DO 3072 J = 1,MNPCS
                IRV(I,L,J) = 0
 3072     CONTINUE
          GO TO 3100
 3076     CONTINUE
C         IF A DYNAMIC SOLUTION FAILS AND AFTERWARDS MEMSOL IS ACCESSED
C         FOR PURPOSES OF PRINTING MEMBER RESULTS AT THE END OF THE LAST
C         STORED TIME STEP, THEN VALUES MUST BE READ OFF UNIT 'IREAD' .
C  NOTE:- ( LOOK FOR COMMENTS IN SUBROUTINE PRINT9 DESCRIBING AT WHAT
C         INTERVALS , VALUES ARE WRITTEN ON THE PERMANENT UNIT . )
C         HENCE THE FOLLOWING STATEMENTS UPTO BEFORE STMNT 3080.
          IF ( IABAN .EQ. 0 ) GO TO 3080
      READ ( IREAD ) ( DX(I), DY(I), DZ(I), I=1,MP2 )
          IF ( INLOPT .EQ. 0 ) GO TO 3300
          IF ( NWRITE .EQ. 0 ) GO TO 3078
      READ (IREAD ) ((WRXM(I,J),WRTXM(I,J),WRYM(I,J),WRTYM(I,J),
     2                WRZM(I,J), WRTZM(I,J), J=1,10), I=2,MP1 )
 3078     CONTINUE
          IF ( MODELT .LE. -1 ) GO TO 3300
          IF (ELEMNT .EQ. SHEAR) GO TO 3079
      READ (IREAD ) (((EPR1S(I,J,K),EPRT1S(I,J,K),EPR2S(I,J,K),
     2                 EPRT2S(I,J,K),K=1,MSSIM1), J=1,MNPCS), I=2,MP1 )
          IF ( MODELT .EQ.  0 ) GO TO 3300
      READ  (IREAD ) (((EPBF1 (I,J,K), EPBFT1(I,J,K), SLBF1 (I,J,K),
     2                  SLBFT1(I,J,K), EPBF2 (I,J,K), EPBFT2(I,J,K),
     3                  SLBF2 (I,J,K), SLBFT2(I,J,K), K=1,MSSIM1 ),
     4                  J = 1,MNPCS ), I = 2,MP1 )
          GO TO 30791
 3079     CONTINUE
      READ (IREAD ) (((EPR1S(I,J,K),EPRT1S(I,J,K),
     2                K = 1,MSSIM1), J=1,MNPCS), I=2,MP1 )
          IF ( MODELT .EQ.  0 ) GO TO 3300
      READ  (IREAD ) (((EPBF1 (I,J,K), EPBFT1(I,J,K), SLBF1 (I,J,K),
     2                  SLBFT1(I,J,K), K=1,MSSIM1 ),J=1,MNPCS),I=2,MP1)
30791     CONTINUE
      READ  (IREAD ) (((EPSMAX(I,L,J), EPSMIN(I,L,J), EPSPRE(I,L,J),
     2                  J = 1,MNPCS ), L = 1,NHINGE ), I = 2,MP1 )
          IF ( MODELT .NE.  2 ) GO TO 3300
      READ  (IREAD ) (((YGROW (I,L,J), YTGROW(I,L,J), J = 1,MNPCS ),
     2                  L = 1,NHINGE ), I = 2,MP1 )
      GO TO 3300
 3080     CONTINUE
      READ  (N1)      ( DX(I), DY(I), DZ(I), I = 1,MP2 )
          IF ( INLOPT .EQ. 0 ) GO TO 3100
          IF ( NWRITE .EQ. 0 ) GO TO 3085
      READ  (N1) ( ( WRXM(I,J), WRTXM(I,J), WRYM(I,J), WRTYM(I,J),
     2WRZM(I,J), WRTZM(I,J), J=1,10), I=2,MP1 )
          IF ( NITM(JJ) .EQ. MNITM+1 ) GO TO 3085
      READ  (N3) ((MCUREV(I,N), N=1,3), I=2,MP1 )
 3085     CONTINUE
          IF ( MODELT .LE. -1 ) GO TO 3100
          IF (ELEMNT .EQ. SHEAR) GO TO 3086
      READ (N1) ((( EPR1S(I,J,K) , EPRT1S(I,J,K), EPR2S(I,J,K),
     2              EPRT2S(I,J,K) , K = 1,MSSIM1), J=1,MNPCS), I=2,MP1 )
          IF ( MODELT .EQ.  0 ) GO TO 3090
      READ  (N1     ) (((EPBF1 (I,J,K), EPBFT1(I,J,K), SLBF1 (I,J,K),
     2                  SLBFT1(I,J,K), EPBF2 (I,J,K), EPBFT2(I,J,K),
     3                  SLBF2 (I,J,K), SLBFT2(I,J,K), K=1,MSSIM1 ),
     4                  J = 1,MNPCS ), I = 2,MP1 )
          GO TO 3088
 3086     CONTINUE
      READ (N1) ((( EPR1S(I,J,K) , EPRT1S(I,J,K),
     2              K = 1,MSSIM1) , J=1,MNPCS), I=2,MP1 )
          IF ( MODELT .EQ.  0 ) GO TO 3090
      READ  (N1     ) (((EPBF1 (I,J,K), EPBFT1(I,J,K), SLBF1 (I,J,K),
     2                  SLBFT1(I,J,K) ,K=1,MSSIM1 ),J=1,MNPCS ),I=2,MP1 )
 3088     CONTINUE
      READ  (N1     ) (((EPSMAX(I,L,J), EPSMIN(I,L,J), EPSPRE(I,L,J),
     2                  J = 1,MNPCS ), L = 1,NHINGE ), I = 2,MP1 )
          IF ( MODELT .NE. 2 ) GO TO 3090
      READ  (N1     ) (((YGROW (I,L,J), YTGROW(I,L,J), J = 1,MNPCS ),
     2                  L = 1,NHINGE ), I = 2,MP1 )
 3090     CONTINUE
          IF ( NITM(JJ) .EQ. MNITM+1 ) GO TO 3300
          IF ( MODELT .LE. -1 ) GO TO 3100
      READ (N3)   (((IRV(I,L,J),J=1,MNPCS),L=1,NHINGE),I=2,MP1)
 3100     CONTINUE
          IF ( IRDYN .EQ. 1 ) GO TO 3500
          IF (NITM(JJ) .EQ. MNITM + 1) GO TO 3300
COMMENT - SKIP FOR FINAL MEMBER SOLUTION
COMMENT - SET MEMBER-END-DISPLACEMENTS IN STRUCTURE COORDINATES DMS
COMMENT - EQUAL TO STRUCTURE JOINT DISPLACEMENTS AT FROM JOINT
                J1I = JT1(JJ)
          IF (JTSHR .NE. JSYES) GO TO 3110
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      IF (JST(J1I) .EQ. 0) GO TO 3110
      IF (DABS(DC1S(ISTT)) .GT. 0.99) KEY=1
      IF (DABS(DC1S(ISTT)) .LE. 0.99) KEY=3
      CALL      TRNSFM (KEY,J1I,TRD,3,4)
                DMS4(1) = DXX(J1I)
                DMS4(2) = DYY(J1I)
                DMS4(3) = DZZ(J1I)
                DMS4(4) = DVV(J1I)
      CALL      MULT (TRD,DMS4,DMS,3,4,1)
          GO TO 3115
 3110 CONTINUE
                DMS(1) = DXX(J1I)
                DMS(2) = DYY(J1I)
                DMS(3) = DZZ(J1I)
 3115     CONTINUE
COMMENT - TRANSFORM DMS TO DMM AT FROM JOINT
       CALL     MATM31 (DC,DMS,DMM)
COMMENT - SET MEMBER END-LOADS TO 1.0E40  TIMES DMM AT FROM JOINT
                ERX(1) = (DMM(1) - DX(1))*1.0E20
      IF (DABS(ERX(1)).LT.1.0E07) ERX(1)=0.0
                ERY(1) = (DMM(2) - DY(1))*1.0E20
      IF (DABS(ERY(1)).LT.1.0E07) ERY(1)=0.0
      IF (IPINLT .EQ. 1) GO TO 3120
                ERZ(1) = (DMM(3) - DZ(1))*1.0E20
      IF (DABS(ERZ(1)).LT.1.0E07) ERZ(1)=0.0
      GO TO 3150
 3120           ERZ(1) = 0.0
 3150     CONTINUE
COMMENT - REPEAT ABOVE FOR TO JOINT
                J2I = JT2(JJ)
      IF (JTSHR .NE. JSYES) GO TO 3160
      IF (JST(J2I) .EQ. 0) GO TO 3160
      IF (DABS(DC1S(ISTT)) .GT. 0.99) KEY=2
      IF (DABS(DC1S(ISTT)) .LE. 0.99) KEY=4
      CALL      TRNSFM (KEY,J2I,TRD,3,4)
                DMS4(1) = DXX(J2I)
                DMS4(2) = DYY(J2I)
                DMS4(3) = DZZ(J2I)
                DMS4(4) = DVV(J2I)
      CALL      MULT (TRD,DMS4,DMS,3,4,1)
          GO TO 3165
 3160 CONTINUE
                DMS(1) = DXX(J2I)
                DMS(2) = DYY(J2I)
                DMS(3) = DZZ(J2I)
 3165     CONTINUE
      CALL      MATM31 (DC,DMS,DMM)
                ERX(MP1) = (DMM(1) - DX(MP1))*1.0E20

      IF (DABS(ERX(MP1)).LT.1.0E07) ERX(MP1)=0.0
                ERY(MP1) = (DMM(2) - DY(MP1))*1.0E20
      IF (DABS(ERY(MP1)).LT.1.0E07) ERY(MP1)=0.0
      IF (IPINRT .EQ. 1) GO TO 3220
                ERZ(MP1) = (DMM(3) - DZ(MP1))*1.0E20
      IF (DABS(ERZ(MP1)).LT.1.0E07) ERZ(MP1)=0.0
      GO TO 3250
 3220           ERZ(MP1) = 0.0
 3250     CONTINUE
 3300     CONTINUE
 3500     CONTINUE
COMMENT - START ITERATIVE SOLUTION FOR MEMBER DISPLACEMENTS CONSISTENT
COMMENT - WITH APPLIED LOADS AND IMPOSED DISPLACEMENTS FROM FRAME
COMMENT - SOLUTION
      IF ( INLOPT .EQ. 0 ) GO TO 3505
COMMENT - THE FOLLOWING STATEMENTS ( UPTO # 3501 ) DETERMINE  THE
C         PROPER VALUE FOR    INDEX .
C         INDEX = 0      UR IS NOT SET EQUAL TO URT
C         INDEX = 1      UR IS     SET EQUAL TO URT
                INDEX = 0
      IF ( NITM(JJ) .EQ. MNITM+1 ) GO TO 3501
      IF ( ITYPE .LE. 2 ) GO TO 35001
      IF ( IRDYN .EQ. 1 ) GO TO 3501
35001     CONTINUE
      IF ( NITF .EQ. 1 .AND. NITERM(JJ) .EQ. 2 ) INDEX = 1
      IF ( ITYPE .GE. 3 ) GO TO 3501
      IF ( ITAPE .EQ. 0 .AND. NITERM(JJ) .EQ. 2 ) INDEX = 1
 3501     CONTINUE
COMMENT - THE FOLLOWING STATEMENTS ( UPTO # 3504 ) DETERMINE THE
C         PROPER VALUE FOR    NCHECK .
C         NCHECK = 0     REVERSAL CHECK IS NOT DONE
C         NCHECK = 1     REVERSAL CHECK IS     DONE
                NCHECK = 0
COMMENT - REVERSAL CHECK MUST NOT BE DONE WHILE TABLE 9 IS BEING PRINTED
      IF ( NITM(JJ) .EQ. MNITM+1 ) GO TO 3504
COMMENT - FOR NITF = 1 ONLY STRAIN REVERSAL CHECK DONE.
      IF ( NITF      .GT. 1         ) GO TO 3504
      IF ( ITYPE     .LE. 2         ) GO TO 3502
COMMENT - REVERSAL CHECK NOT NEEDED IN FIRST TIME STEP
      IF ( JT        .EQ. 1         ) GO TO 3504
COMMENT - IN THE DYNAMIC ANALYSIS, REVERSAL CHECK IS NEEDED ONLY WHEN
COMMENT - THE PARTICULAR TIME STEP IS BEING EXECUTED FOR THE FIRST
COMMENT - INSTANT. IT IS NOT APPLICABLE WHEN A PARTICULAR TIME STEP
COMMENT - IS APPROACHED ONCE AGAIN AS A CONSEQUENCE OF SENSING OF REVRSL
      IF ( IRSTEP(JT)+IRDYN .EQ. 0 ) GO TO 3502
      GO TO 3504
 3502     CONTINUE
COMMENT - ELEMENTS FEEL THE EFFECT OF NEW JOINT DISPLACEMENTS IN THE
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COMMENT - 2 ND ITERATION OF THE MEMBER ONLY. SO STRAIN REVERSAL CHECK
COMMENT - IS TO BE DONE CORRESPONDING TO THIS CASE.HENCE THE NEXT STTMNT
          IF ( NITERM(JJ) .EQ. 2 ) GO TO 3503
          GO TO 3504
 3503     CONTINUE
                NCHECK = 1
 3504     CONTINUE
                KOPFCW = 0
          IF ( NWRITE .NE. 0 ) GO TO 33500
          DO 33400 I = 1,MP2
                SX  (I) = 0.0
                SY  (I) = 0.0
                SZ  (I) = 0.0
                SQX (I) = 0.0
                SQY (I) = 0.0
                SQZ (I) = 0.0
33400     CONTINUE
          GO TO 33800
33500     CONTINUE
          IF ( INDEX .NE. 1 ) GC TO 33700
          DO 33600 I = 2,MP1
          DO 33600 J = 1,10
                WRXM(I,J) = WRTXM(I,J)
                WRYM(I,J) = WRTYM(I,J)
                WRZM(I,J) = WRTZM(I,J)
33600     CONTINUE
33700     CONTINUE
      CALL NLSS ( L1, JJ )
33800     CONTINUE
COMMENT - STORE MEMBER - END - RESTRAINTS (NONLINEAR SPRINGS)
                ST1 = SX(1)
                ST2 = SY(1)
                ST3 = SZ(1)
                ST4 = SX(MP1)
                ST5 = SY(MP1)
                ST6 = SZ(MP1)
 3505 CONTINUE
          IF ( IRDYN .EQ. 1 ) GO TO 3515
COMMENT - SET MEMBER END RESTRAINTS EQUAL TO 1.0E20 FOR MEMBER SOLUTION
                SX(1) = 1.0E20
                SY(1) = 1.0E20
                SZ(1) = 1.0E20
                SX(MP1) = 1.0E20
                SY(MP1) = 1.0E20
                SZ(MP1) = 1.0E20
COMMENT - ZERO PINNED END ROTATIONAL RESTRAINTS
          IF (IPINLT .EQ. 1) SZ(1) = 0.0
          IF (IPINRT .EQ. 1) SZ(MP1) = 0.0
COMMENT - ZERO INTERIOR STATION EQUILIBRIUM ERRORS
          DO 3510  I = 2,M
                ERX(I) = 0.0
                ERY(I) = 0.0
 3510           ERZ(I) = 0.0
 3515     CONTINUE
                NITM(JJ) = NITM(JJ) + 1
                NITM1 = NITM(JJ) - 1
                KOPFSE = 0
          IF ( MODELT .LE. -1 ) GC TO 3519
          IF ( INDEX  .NE.  1 ) GC TO 3519
          IF (ELEMNT .EQ. SHEAR) GO TO 35151
          DO 3516 I = 2,MP1
          DO 3516 J = 1,MNPCS
          DO 3516 K = 1,MSSIM1
                EPR1S(I,J,K) = EPRT1S(I,J,K)
                EPR2S(I,J,K) = EPRT2S(I,J,K)
 3516     CONTINUE
          IF ( MODELT .EQ. 0 ) GO TO 3519
          DO 3517 I = 2,MP1
          DO 3517 J = 1,MNPCS
          DO 3517 K = 1,MSSIM1
                EPBF1(I,J,K) = EPBFT1(I,J,K)
                SLBF1(I,J,K) = SLBFT1(I,J,K)
                EPBF2(I,J,K) = EPBFT2(I,J,K)
                SLBF2(I,J,K) = SLBFT2(I,J,K)
 3517     CONTINUE
          GO TO 35172
35151     CONTINUE
          DO 35161 I = 2,MP1
          DO 35161 J = 1,MNPCS
          DO 35161 K = 1,MSSIM1
                EPR1S(I,J,K) = EPRT1S(I,J,K)
35161     CONTINUE
          IF ( MODELT .EQ. 0 ) GO TO 3519
          DO 35171 I = 2,MP1
          DO 35171 J = 1,MNPCS
          DO 35171 K = 1,MSSIM1
                EPBF1(I,J,K) = EPBFT1(I,J,K)
                SLBF1(I,J,K) = SLBFT1(I,J,K)
35171     CONTINUE
35172 CONTINUE
          DO 3518 I = 2,MP1
          DO 3518 L = 1,NHINGE
          DO 3518 J = 1,MNPCS
          IF ( EPSPRE(I,L,J) .GT. EPSMAX(I,L,J) )
     2          EPSMAX(I,L,J) = EPSPRE(I,L,J)
          IF ( EPSPRE(I,L,J) .LT. EPSMIN(I,L,J) )
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     2          EPSMIN(I,L,J) = EPSPRE(I,L,J)
          IF ( MODELT .NE. 2 ) GO TO 3518
                YGROW(I,L,J) = YTGROW(I,L,J)
 3518     CONTINUE
 3519     CONTINUE
COMMENT - DO FOR EACH ELEMENT
          DO 3600  I = 2,MP1
                IM1 = I - 1
COMMENT - COMPUTE FORCES ON ENDS OF DISCRETE ELEMENT
COMMENT - IT IS IMPORTANT TO REMEMBER THAT ONLY DURING THE 2ND ITERATION
COMMENT - OF THE MEMBER (NITM(JJ) = NITERM(JJ) = 2 ),THE ELEMENTS FEEL
COMMENT - THE EFFECT OF UPDATED JOINT DISPLACEMENTS OF THE MEMBER ENDS
      CALL        ELEMFO  (DX(IM1),DY(IM1),DZ(IM1),DX(I),DY(I),DZ(I),I,
     2    U1T,V1T,W1T,U2T,V2T,W2T,ELEMNT)
COMMENT - STORE END FORCES OF END ELEMENTS ONLY, FOR USE LATER IN MEMEND
          IF ( I .NE. 2 ) GO TO 3520
                ENDFOR (JJ,1) = U1T
                ENDFOR (JJ,2) = V1T
                ENDFOR (JJ,3) = W1T
 3520     IF ( I .NE. MP1 ) GO TO 3525
                ENDFOR (JJ,4) = U2T
                ENDFOR (JJ,5) = V2T
                ENDFOR (JJ,6) = W2T
 3525 CONTINUE
          IF ( IRDYN .EQ. 1 ) GO TO 3600
          IF (NITM(JJ) .NE. MNITM + 2) GO TO 3530
                U1(I) = U1T
                V1(I) = V1T
                W1(I) = W1T
                U2(I) = U2T
                V2(I) = V2T
                W2(I) = W2T
          GO TO 3600
 3530     CONTINUE
COMMENT - IF REVERSAL HAS NOT BEEN SENSED SO FAR ANYWHERE, THEN GO AHEAD
COMMENT - WITH EQUILIBRIUM COMPUTATIONS.
          IF ( IRVRSE .EQ. 0 ) GO TO 3540
COMMENT - IF REVERSAL HAS BEEN SENSED SOMEWHERE, AT THIS STAGE,THEN
COMMENT - SKIP EQUILIBRIUM COMPUTATIONS.  **** HOWEVER, THE MEMBER
COMMENT - MUST GO THROUGH THE 2ND ITERATION(NITM(JJ)=NITERM(JJ)=2)
COMMENT - SO THAT SCANNING AND IDENTIFICATION IS DONE OF THOSE
COMMENT - SUBRECTANGLES OF THOSE ELEMENTS WHICH HAVE REVERSED. THIS
COMMENT - ENSURES THAT THE PROPER STIFFNESS MATRIX IS FORMED IN  FORMST
COMMENT - IN THE NEXT FRAME ITERATION ( NITF = 2 )
COMMENT - THE FOLLOWING STATEMENT SERVES THIS PURPOSE
          IF ( NITERM(JJ) .EQ. 1 ) GO TO 3540
          GO TO 3600
 3540     CONTINUE
COMMENT - COMPUTE PARTIAL EQUILIBRIUM ERRORS BY SUMMING FORCES ON
COMMENT - ADJACENT ELEMENTS
          IF (I .EQ. 2 .AND. IPINLT .EQ. 1) ERZ(1) = W1T
          IF (I .EQ. 2) GO TO 3550
                ERX(IM1) = ERX(IM1) + U1T
                ERY(IM1) = ERY(IM1) + V1T
                ERZ(IM1) = ERZ(IM1) + W1T
          IF ( I .EQ. MP1 .AND. IPINRT .EQ. 1) ERZ(MP1) = W2T
          IF (I .EQ. MP1) GO TO 3600
 3550           ERX(I) = ERX(I) + U2T
                ERY(I) = ERY(I) + V2T
                ERZ(I) = ERZ(I) + W2T
 3600     CONTINUE
          IF ( IRDYN .EQ. 1 ) GO TO 4300
COMMENT - SKIP FOR FINAL MEMBER SOLUTION
          IF (NITM(JJ) .EQ. MNITM + 2) GO TO 4300
COMMENT - THE COMMENTS REGARDING EQUILIBRIUM CALCULATIONS THAT ARE
COMMENT - PRESENT INSIDE THE  DO 3600  LOOP ABOVE APPLY HERE ALSO.
          IF ( IRVRSE .EQ. 0 ) GO TO 3700
          IF ( NITERM(JJ) .EQ. 1 ) GO TO 3700
          GO TO 4475
 3700     CONTINUE
COMMENT - DO FOR EACH INTERIOR STATION
          DO 3800  I = 2,M
COMMENT - ADD STATIONS LOADS AND STATION RESISTIVE SPRING FORCES TO
COMMENT - COMPLETE COMPUTATION OF EQUILIBRIUM ERRORS
          IF (INLOPT .EQ. 0) SQX(I) = -SX(I)*DX(I)
                ERX(I) = QX(I) - ERX(I) + SQX(I)
          IF (INLOPT .EQ. 0) SQY(I) = -SY(I)*DY(I)
                ERY(I) = QY(I) - ERY(I) + SQY(I)
          IF (INLOPT .EQ. 0) SQZ(I) = -SZ(I)*DZ(I)
                ERZ(I) = QZ(I) - ERZ(I) + SQZ(I)
 3800     CONTINUE
          IF (INLOPT .EQ. 0) SQZ(1) = -SZ(1)*DZ(1)
          IF (IPINLT .EQ. 1) ERZ(1) = QZ(1) -ERZ(1) + SQZ(1)
          IF (INLOPT .EQ. 0) SQZ(MP1) = -SZ(MP1)*DZ(MP1)
          IF (IPINRT .EQ. 1) ERZ(MP1) = QZ(MP1) -ERZ(MP1) + SQZ(MP1)
COM       IF (NITM1 .EQ. 0) GO TO 3815
          IF ( APROB .EQ. PRINT .OR. APROB .EQ. MEMBER ) GO TO 3801
          GO TO 3802
 3801     CONTINUE
          IF (IMM(JJ) .EQ. 0) GO TO 3815
COMMENT - PRINT DISPLACEMENTS AND EQUILIBRIUM ERRORS AT FIRST INTERIOR
COMMENT - STATIONS AND CENTER STATION FOR MONITOR MEMBERS
      PRINT 51, JJ,  NITM1,     DX(2), DY(2), DZ(2), ERX(2), ERY(2),
     2    ERZ(2), DX(MP22),DY(MP22),DZ(MP22),ERX(MP22),ERY(MP22),
     3    ERZ(MP22),DX(M),DY(M),DZ(M),ERX(M),ERY(M),ERZ(M)
 3802     CONTINUE
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      IF (KOPFOW .EQ. 1) PRINT 54
      IF (KOPPSE .EQ. 1) PRINT 55
      IF ( APROB .EQ. MEMBER ) GO TO 38022
      IF (APROB .NE. PRINT) GC TO 3815
38022 CONTINUE
COMMENT - DUMP OF ALL STATION DISPLACEMENTS AND EQUILIBRIUM ERRORS, TO
COMMENT - ACTIVATE SET LAST FIVE COLUMNS IN PROBLEM NUMBER CARD EQUAL
COMMENT - TO PRINT, OR THE LAST  6  CCLUMNS TO  MEMBER
COMMENT - ( ALONG WITH THE PRINTED VALUES, THE LATERAL DISPLACEMENTS
COMMENT - ARE ALSO PLCTTED FOR QUICK VISUAL ANALYSIS )
   PRINT 40
          SCALE = 0.0
      DO 3803 I = 1,MP1
          TEMP = DABS ( DY(I) )
      IF ( TEMP .GT. SCALE ) SCALE = TEMP
 3803 CONTINUE
          SCALE = SCALE / 2.0
      DO 3805 I = 1,MP1
      DO 3804 II = 1,41
 3804     ALPHA(II) = A
          ALPHA(21) = C
      IF ( SCALE .GT. 1.0D-15 ) GO TO 33804
          NTEMP = 21
      GO TO 33808
33804 CONTINUE
          NTEMP = 10.0 * DY(I) / SCALE + 21.5
33808 CONTINUE
          ALPHA (NTEMP) = B
   PRINT 45, DX(I), DY(I), DZ(I), ERX(I), ERY(I), ERZ(I),
  2       ( ALPHA(II), II=1,41 )
 3805 CONTINUE
 3815 CONTINUE
      IF ( IRVRSE .NE. 0 ) GO TO 3880
COMMENT - COMPARE EQULIBRIUM ERRORS WITH SPECIFED TOLERANCES
      DO 3825  I = 1,MP1
      IF(DABS(ERX(I)) .GT. ER1)  GO TO 3850
      IF(DABS(ERY(I)) .GT. ER1)  GC TO 3850
      IF(DABS(ERZ(I)) .GT. ER2)  GO TC 3850
 3825 CONTINUE
      GO TO 4200
 3850 CONTINUE
      IF (NITM(JJ) .LE. MNITM)   GO TO 3880
COMMENT - IF MAXIMUM NUMBER OF MEMBER ITERATIONS SET IMC = 1 AND STOP
COMMENT - ITERATION PROCESS
          IMC(JJ) = 1
      GO TO 4250
COMMENT - SOLVE MEMBER FOR LINEAR INCREMENTS OF DISPLACEMENT
 3880     M5 = 5
      CALL GRIP2A (RM,RO,W,SL,L3,L4,L6,M5)
      IF (M5 .LT. 10000) GO TC 3890
          IMC(JJ) = 1
   GO TO 4475
COMMENT - INCREMENT MEMBER DISPLACEMENTS
 3890     J = 1
      DO 3900  I = 1,MP1
          DX(I) = DX(I)  + W(J)
          J = J + 1
          DY(I) = DY(I)  + W(J)
          J = J + 1
          DZ(I) = DZ(I)  + W(J)
          J = J + 1
 3900 CONTINUE
COMMENT - ZERO EQUILIBRIUM ERRORS AT END STATIONS
          ERX(1) = 0.0
          ERY(1) = 0.0
          ERZ(1) = 0.0
          ERX(MP1) = 0.0
          ERY(MP1) = 0.0
          ERZ(MP1) = 0.0
          NITERM (JJ) = NITERM (JJ) + 1
      GO TO 3500
 4200 CONTINUE
      IF ( APROB .EQ. PRINT .OR. APROB .EQ. MEMBER ) GO TO 4210
      GO TO 4300
 4210 CONTINUE
   PRINT 52, JJ, NITM1
      GO TO 4300
 4250 PRINT 53, JJ, NITM1
COMMENT - CALCULATE MEMBER - END - FORCES
 4300 CALL    MEMEND ( FMM,L6,JJ )
      IF (NITM(JJ) .NE. MNITM + 2) GO TO 4350
          U1(2) = FMM(1)
          V1(2) = FMM(2)
          W1(2) = FMM(3)
          U2(MP1) = FMM(4)
          V2(MP1) = FMM(5)
          W2(MP1) = FMM(6)
      GO TO 4475
 4350 CONTINUE
COMMENT - SUBTRACT MEMBER - END - FORCES FROM JOINT EQUILIBRIUM ERRORS
COMMENT - TO COMPLETE COMPUTATION OF JOINT EQUILIBRIUM ERRORS
      CALL    ADJTER ( FMM(1),FMM(4),JT1(JJ),JT2(JJ),DC1S(ISTT),
     2   DC2S(ISTT))
COMMENT - STORE MEMBER - END - FORCES AS MEMBER INCREMENTAL FIXED -
COMMENT - END - FORCES TO CALCULATE INCREMENTAL FIXED - END- FORCES
COMMENT - IN NEXT PROBLEM
```

```
      DO 4400  I = 1,6
4400     FOMM(JJ,I) = FMM(I)
4475  CONTINUE
      IF ( ITYPE .GE. 3 .AND. IABAN .EQ. 1 ) GO TO 9900
COMMENT - STORE MEMBER DISPLACEMENTS
      WRITE (N2)    (DX(I),DY(I),DZ(I)  ,I=1,MP2)
COMMENT - SKIP FOR LINEAR STIFFNESS TYPE
      IF ( INLOPT .EQ. 0 ) GO TO 9900
COMMENT - SKIP IF MEMBER-SUPPORT SPRINGS DO NOT EXIST
      IF ( NWRITE .EQ. 0 ) GO TO 4500
COMMENT - STORE RESIDUAL& TEMPORARY RESIDUAL DISPLACEMENTS OF
COMMENT - MEMBER SUPPORT CURVES ( THEIR COMPONENTS )
      WRITE (N2) ( ( WRXM(I,J), WRTXM(I,J), WRYM(I,J), WRTYM(I,J),
     2WRZM(I,J), WRTZM(I,J), J=1,10), I=2,MP1 )
      IF ( NITM(JJ) .EQ. MNITM+2 ) GO TO 4500
COMMENT - WRITE REVERSAL INDICATORS FOR MEMBER-SUPPORT SPRINGS
      WRITE (N4) ((MCUREV(I,N), N=1,3), I=2,MP1 )
4500  CONTINUE
      IF ( MODELT .LE. -1 ) GO TO 9900
COMMENT - STORE RESIDUAL & TEMPORARY RESIDUAL STRAINS
      IF (ELEMNT .EQ. SHEAR) GO TO 4550
      WRITE(N2) ((( EPR1S(I,J,K) , EPRT1S(I,J,K), EPR2S(I,J,K),
     2             EPRT2S(I,J,K) , K = 1,MSSIM1), J=1,MNPCS), I=2,MP1 )
      IF ( MODELT .EQ. 0 ) GO TO 4600
      WRITE (N2    ) (((EPBF1 (I,J,K), EPBFT1(I,J,K), SLBF1 (I,J,K),
     2                  SLBFT1(I,J,K), EPBF2 (I,J,K), EPBFT2(I,J,K),
     3                  SLBF2 (I,J,K), SLBFT2(I,J,K), K=1,MSSIM1 ),
     4                  J = 1,MNPCS ), I = 2,MP1 )
      GO TO 4560
4550  CONTINUE
      WRITE (N2) ((( EPR1S(I,J,K), EPRT1S(I,J,K),
     2             K = 1,MSSIM1), J=1,MNPCS), I=2,MP1 )
      IF ( MODELT .EQ. 0 ) GO TO 4600
      WRITE (N2    ) (((EPBF1 (I,J,K), EPBFT1(I,J,K) , SLBF1 (I,J,K),
     2                  SLBFT1(I,J,K), K=1,MSSIM1 ),J=1,MNPCS),I=2,MP1)
4560  CONTINUE
      WRITE (N2    ) (((EPSMAX(I,L,J), EPSMIN(I,L,J), EPSPRE(I,L,J),
     2                  J = 1,MNPCS ), L = 1,NHINGE ), I = 2,MP1 )
      IF ( MODELT .NE. 2 ) GO TO 4600
      WRITE (N2    ) (((YGROW (I,L,J), YTGROW(I,L,J), J = 1,MNPCS ),
     2                  L = 1,NHINGE ), I = 2,MP1 )
4600  CONTINUE
      IF ( NITM(JJ) .EQ. MNITM+2 ) GO TO 9900
C
COMMENT - WRITE REVERSAL INDICATORS FOR STRAINS
C
      WRITE (N4) (((IRV(I,L,J),J=1,MNPCS),L=1,NHINGE),I=2,MP1)
9900  CONTINUE
      RETURN
      END


************************************ SUBROUTINE ************************************
      SUBROUTINE ELEMFO (DX1,DY1,DZ1,DX2,DY2,DZ2,I,U1T,V1T,W1T,U2T,V2T,
     2    W2T,ELEMNT)
COMMENT - SUBROUTINE ELEMFO EVALUATES THE END-FORCES ON A DISCRETE
COMMENT - ELEMNT, GIVEN THE ELEMENT-END-DISPLACEMENTS
      IMPLICIT REAL*8 (A-H,O-Z)
      DOUBLE PRECISION DCOS,DSIN,DATAN
      DIMENSION D(6,6)
      DIMENSION CURVAT(22), GAMMA(22), BMS(22), SHS(22)
      COMMON /BLOCK7/ F( 22),      AE( 22),     SX( 22),     SY( 22),
     2    SZ( 22),     QX( 22),     QY( 22),     QZ( 22),     DX( 22),
     3    DY( 22),     DZ( 22),     ERX( 22),    ERY( 22),    ERZ( 22),
     4    SQX( 22),    SQY( 22),    SQZ( 22),    U1( 22),     V1( 22),
     5    W1( 22),     U2( 22),     V2( 22),     W2( 22),     DS(3,3, 22),
     6    BM1S( 22),   BM2S( 22),   TTS( 22),    AG( 22)
      COMMON /BLK2/ XL,XR,X1,X2,            H,TH,HSQ,HCU,X2L,I1,I2,NQ
      COMMON /SKT23/ PDELTA
      COMMON /SKT29/ EPSLON(22), CURVA1(22), CURVA2(22)
      EQUIVALENCE (CURVAT(1),CURVA1(1)) , (GAMMA(1),CURVA2(1)) ,
     2            (BMS(1),BM1S(1)) , (SHS(1),BM2S(1))
            DATA PDNO /4HPDNO/, PDN /4H PDN/
            DATA SHEAR /5HSHEAR/
      IF (ELEMNT .EQ. SHEAR) GO TO 3000
COMMENT - COMPUTE THE ELEMENT DEFORMATIONS
            DDX = DX2 - DX1
            DDY = DY2 - DY1
      IF ( PDELTA.EQ.PDNO .OR. PDELTA.EQ.PDN ) GO TO 200
      GO TO 300
200   CONTINUE
COMMENT - COMPUTE DEFORMATIONS BASED ON SMALL DISPLACEMENTS
            S      = DDY - 0.5 * H * ( DZ1+DZ2 )
            DELTA  = DDX
            THETA  = S / H
      GO TO 400
300   CONTINUE
            COSIM1 =DCOS(DZ1)
            COSI   =DCOS(DZ2)
            SINIM1 =DSIN(DZ1)
            SINI   =DSIN(DZ2)
            COSCOS = COSI + COSIM1
            SINSIN = SINI + SINIM1
            E = DDX + H*(1.0 - 0.5*COSCOS)
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              S = DDY - 0.5*H*SINSIN
              DELTA = ((H + R)*(H + R) + S*S)**0.5 - H
              TTHETA = S/(H + R)
              THETA = DATAN(TTHETA)
              SINT = S/(H + DELTA)
              COST = (H + R)/(H + DELTA)
  400     CONTINUE
              TAU1 = THETA -  DZ1
              TAU2 =  DZ2 - THETA
COMMENT - STORE STRAIN AND THE TWC CURVATURES OF EACH ELEMENT FOR OUTPUT
              EPSLCN(I) = DELTA / TH
              CURVA1(I) = TAU1 / H
              CURVA2(I) = TAU2 / H
COMMENT - CALL FAEREV TO FIND INTERNAL FORCES IN ELEMENT TT,BM1,BM2
      CALL        FAEREV (DELTA, TAU1, TAU2, I, D, TT, BM1, BM2 )
          IF ( PDELTA.EQ.PDNO .OR. PDELTA.EQ.PDN ) GO TO 500
          GO TO 600
  500     CONTINUE
              V1T = ( BM2 - BM1 ) / H
              U2T =  TT
              V2T = -V1T
              U1T = -U2T
              W1T = -BM1 + 0.5 * V1T * H
              W2T =  BM2 + 0.5 * V1T * H
          GO TO 1000
  600     CONTINUE
              VT  = (BM2 - BM1) /(H + DELTA)
              U2T = TT*COST   + VT*SINT
              V2T = TT*SINT   -  VT*COST
              U1T = -U2T
              V1T = -V2T
              W1T = -BM1 + 0.5*(- U1T*SINIM1 +  V1T*CCSIM1)*H
              W2T =  BM2 + 0.5*(- U1T*SINI   +  V1T*CCSI  )*H
COMMENT - STORE FOR USE BY ELEMST
COMMENT - INCIDENTALLY BM1 & BM2 ARE ALSO STORED FOR OUTPUT PURPOSES.
 1000     CONTINUE
          DO 2100  J = 1,3
          DO 2100  K = 1,3
 2100         DS(J,K,I) = D(J,K)
              TTS(I) =TT
              BM1S(I) = BM1
              BM2S(I) = BM2
          GO TO 9999
 3000     CONTINUE
COMMENT - COMPUTE ELEMENT DEFCRMATIONS
              DDX = DX2 - DX1
              DDY = DY2 - DY1
              DDZ = DZ2 - DZ1
          IF (PDELTA .EQ. PDNO .OR. PDELTA .EQ. PDN ) GO TO 3200
          GO TO 3300
 3200     CONTINUE
COMMENT - COMPUTE DEFORMATICNS BASED ON SMALL DISPLACEMENTS
              THETA  = DDY/TH
              DELA   = DDX
              PSI1   = DZ1 - THETA
              PSI2   = DZ2 - THETA
              DELS   = H*(PSI1 + PSI2)
              DELM   = DDZ
          GO TO 3400
 3300     CONTINUE
              THDX = TH + DDX
              THETA = DATAN(DDY/THDX)
              PSI1 = DZ1 - THETA
              PSI2 = DZ2 - THETA
              SINT = DSIN(THETA)
              COST = DCOS(THETA)
              COS1 = DCOS(PSI1)
              COS2 = DCOS(PSI2)
              SIN1 = DSIN(PSI1)
              SIN2 = DSIN(PSI2)
              COSCCS = CCS1 + COS2
              SINSIN = SIN1 + SIN2
              DELA = THDX/COST - H*CCSCOS
              DELS = H*SINSIN
              DELM = DDZ
 3400     CONTINUE
COMMENT - STORE AXIAL & SHEAR STRAINS AND THE CURVATURE OF EACH ELEMENT
COMMENT - FOR OUTPUT
              EPSLCN(I) = DELA/TH
              CURVAT(I) = DELM/TH
              GAMMA(I)  = DELS/TH
COMMENT - CALL DETAMS TO FIND INTERNAL FORCES TT,BM,SH IN SHEAR ELEMENT
      CALL        DETAMS (DELA,DELM,DELS,I,D,TT,BM,SH)
          IF (PDELTA .EQ. PDNC .OR. PDELTA .EQ. PDN ) GO TO 3500
          GO TO 3600
 3500     CONTINUE
              U1T = -TT
              V1T = SH
              W1T = -BM + H*SH
              U2T = TT
              V2T = -SH
              W2T = BM + H*SH
          GO TO 4000
 3600     CONTINUE
              DELAD2 = DELA/2.0
              DELSD2 = DELS/2.0
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              U1T     = -TT*COST - SH*SINT
              V1T     = -TT*SINT + SH*COST
              W1T     = -BM + SH*(H*COS1 + DELAD2) +
     2        TT*(H*SIN1 - DELSD2)
              U2T     = -U1T
              V2T     = -V1T
              W2T     = BM + SH*(H*COS2 + DELAD2) +
     2        TT*(H*SIN2 - DELSD2)
COMMENT - STORE FOR USE BY ELEMST
COMMENT - INCIDENTALLY TT,BM & SH ARE STORED FOR OUTPUT PURPOSES
 4000         CONTINUE
              DO 4100  J = 1,3
              DO 4100  K = 1,3
 4100             DS(J,K,I) = D(J,K)
                  TTS(I) = TT
                  BMS(I) = BM
                  SHS(I) = SH
 9999         CONTINUE
          RETURN
          END


 ************************************ SUBROUTINE ************************************
          SUBROUTINE MEMEND ( FMM,L6,JJ )
COMMENT - MEMEND EVALUATES THE TOTAL FORCES ON THE ENDS OF THE MEMBERS
          IMPLICIT REAL*8 (A-H,O-Z)
          DIMENSION FMM(6),SA(3,3),WT(3),FT(3)
          COMMON /BLOCK2/ DXS( 25),     DYS( 25),     ZLS( 25),    DC1S( 25),
     2        DC2S( 25),    PRF( 25),     PRAE( 25),    QM( 25),     WM( 25),
     3        PRAG(25),     ELEMN(25),
     4        IOPOP( 25),   IPINL( 25),   IPINR( 25),   NC51( 25),   INLOP( 25),
     5        NAL( 25),     NSXL( 25),    NSYL( 25),    NSZL( 25),   NAR( 25),
     6        NSXR( 25),    NSYR( 25),    NSZR( 25),    NCDS( 25),   IAXOPS( 25)
          COMMON /BLOCK7/ F( 22),       AE( 22),      SX( 22),     SY( 22),
     2        SZ( 22),      QX( 22),      QY( 22),      QZ( 22),     DX( 22),
     3        DY( 22),      DZ( 22),      ERX( 22),     ERY( 22),    ERZ( 22),
     4        SQX( 22),     SQY( 22),     SQZ( 22),     U1( 22),     V1( 22),
     5        W1( 22),      U2( 22),      V2( 22),      W2( 22),     DS(3,3, 22),
     6        BM1S( 22),    BM2S( 22),    TTS( 22),     AG( 22)
          COMMON /BLK1/  TOL,     ELEMNT,NJST,   KEEP3C,NCD3C,
     2              KEEP2, KEEP3A,KEEP3B,KEEP4A,KEEP4B,KEEP4C,KEEP5A,
     3              KEEP5B,KEEP5C,KEEP5D,KEEP6, KEEP7, NCD2,  NCD3A,
     4              NCD3B, NCD4A, NCD4B, NCD4C, NCD5A, NCD5B, NCD5C,
     5              NCD5D, NCD6,  NCD7,  IP8,   IP9,   IP10,  ITYPE,
     6              IABAN, IFORM, NM,    NJT,   NST,   NLT,   M,
     7              MP1,   MP2,   ISTT,  LTT,   ITYPEL,IDJ,   NSTL
          COMMON /BLK4/ ST1,ST2,ST3,ST4,ST5,ST6
          COMMON /BLK6/ QT1,QT2,QT3,QT4,QT5,QT6
          COMMON /BLK7/ INLOPT,IFAE,KOFFJ,KOFFQW,KOFFSE
          COMMON /SKT9/       ENDFOR(50,6)
                IAXCPT = IAXOPS(ISTT)
COMMENT - MAKE USE OF THE RELEVANT END FORCES THAT WERE STORED IN MEMSOL
                U1T = ENDFOR (JJ,1)
                V1T = ENDFCR (JJ,2)
                W1T = ENDFOR (JJ,3)
                U2T = ENDFOR (JJ,4)
                V2T = ENDFOR (JJ,5)
                W2T = ENDFOR (JJ,6)
COMMENT - ADD ON THE LOADS ON THE END-STATIONS AND THE RESISTIVE SPRING
COMMENT - FORCES ON THE END-STATIONS
             IF (INLOPT .EQ. 0) SQX(1) = -ST1*DX(1)
                FMM(1) = U1T - SQX(1) - QT1
             IF (INLOPT .EQ. 0) SQY(1) = -ST2*DY(1)
                FMM(2) = V1T - SQY(1) - QT2
             IF (INLOPT .EQ. 0) SQZ(1) = -ST3*DZ(1)
                FMM(3) = W1T - SQZ(1) - QT3
             IF (INLOPT .EQ. 0) SQX(MP1) = -ST4*DX(MP1)
                FMM(4) = U2T -SQX(MP1) - QT4
             IF (INLOPT .EQ. 0) SQY(MP1) = -ST5*DY(MP1)
                FMM(5) = V2T -SQY(MP1) - QT5
             IF (INLOPT .EQ. 0) SQZ(MP1) = -ST6*DZ(MP1)
                FMM(6) = W2T - SQZ(MP1) - QT6
          RETURN
          END


 ************************************ SUBROUTINE ************************************
          SUBROUTINE ADJTER (F1M, F2M, J1, J2, DC1, DC2)
COMMENT - SUBROUTINE ADJTER TRANSFORMS MEMBER-END-FORCES TO STRUCTURE
COMMENT - COORDINATES AND SUBTRACTS FROM APPRCPRIATE JOINT EQUILIBRIUM
COMMENT - ERROR FOR FRAME
          IMPLICIT REAL*8 (A-H,O-Z)
          REAL*8 JTSHR,JSYES
          DIMENSION  F1M(3), F2M(3), F1S(3), F2S(3)
          DIMENSION  DCT(3,3)
          DIMENSION TRD(4,4),TRDT(4,4),F1S4(4),F2S4(4)
          CCMMON /BLOCK1/ X(25),        Y(25),        QXX(25),     QYY(25),
     2        QZZ(25),      SXX(25),      SYY(25),      SZZ(25),     DXX(25),
     3        DYY(25),      DZZ(25),      RXX(25),      RYY(25),     RZZ(25),
     4        ERXX(25),     ERYY(25),     ERZZ(25),     QMJ(25),     WMJ(25),
     5        NSXX(25),     NSYY(25),     NSZZ(25),     IMJ(25),     NSXP(25),
     6        NSYP(25),     ISTJR(25)
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      COMMON /BALA01/ CVV(25),    SVV(25),    DVV(25),    ERVV(25),
     2     RVV(25),   NSVV(25)
      COMMON /BALA02/ JST(25),NJSS(25),HLJ(25),HRJ(25),VLJ(25),VUJ(25),
     2     THKJ(25),GJ(25),SJC(25)
      COMMON /BLOC22/ FJXT(25),FJYT(25),FJZT(25),FJVT(25),
     2     DFJXT(25),DFJYT(25),DFJZT(25),DFJVT(25)
      COMMON /BLK1/  TOL,    ELEMNT,NJST,   KEEP3C,NCD3C,
     2         KEEP2, KEEP3A,KEEP3B,KEEP4A,KEEP4B,KEEP4C,KEEP5A,
     3         KEEP5B,KEEP5C,KEEP5D,KEEP6, KEEP7, NCD2,  NCD3A,
     4         NCD3B, NCD4A, NCD4B, NCD4C, NCD5A, NCD5B, NCD5C,
     5         NCD5D, NCD6,  NCD7,  IP8,   IP9,   IP10,  ITYPE,
     6         IABAN, IFORM, NM,    NJT,   NST,   NLT,   M,
     7         MP1,   MP2,   ISTT,  LTT,   ITYPEL,IDJ,   NSTL
      COMMON /SKT34/ ERXXDN(25), ERYYDN(25), ERZZDN(25), ERVVDN(25)
      COMMON /CHAN1/ JTSHR
               DATA JSYES /5HJSYES/
COMMENT - FORM TRANSPOSE OF MEMBER TRANSFORMATION MATRIX
               DCT(1,3) = 0.0
               DCT(2,3) = 0.0
               DCT(3,1) = 0.0
               DCT(3,2) = 0.0
               DCT(3,3) = 1.0
               DCT(1,1) = DC1
               DCT(1,2) = -DC2
               DCT(2,1) = DC2
               DCT(2,2) = DC1
COMMENT - TRANSFORM MEMBER-END-FORCES AT FROM JOINT TO STRUCTURE COORD
      CALL        MATM31 (DCT,F1M,F1S)
COMMENT - TRANSFORM MEMBER-END-FORCES AT TO JOINT TO STRUCTURE COORD
      CALL        MATM31 (DCT,F2M,F2S)
          IF (JTSHR .EQ. JSYES) GO TO 100
COMMENT - ACCUMULATE JOINT EQUILIBRIUM ERROR AT MEMBERS FROM JOINT
               ERXX(J1) = ERXX(J1) - F1S(1)
               ERYY(J1) = ERYY(J1) - F1S(2)
               ERZZ(J1) = ERZZ(J1) - F1S(3)
COMMENT - ACCUMULATE JOINT EQUILIBRIUM ERROR AT MEMBERS TO JOINT
               ERXX(J2) = ERXX(J2) - F2S(1)
               ERYY(J2) = ERYY(J2) - F2S(2)
               ERZZ(J2) = ERZZ(J2) - F2S(3)
          IF ( ITYPE .LE. 2 ) GO TO 140
COMMENT - STORE CONTRIBUTION OF MEMBER END FORCES ALONE IN A SPECIAL
COMMENT - JOINT ERROR VECTOR FOR USE IN DYNAMIC PROBLEM ONLY
COMMENT - (USEFUL IN CASES WHERE JOINT HAS A LARGE APPLIED FORCE
COMMENT -  TO CONTROL A DISPLACEMENT OR AN ACCELERATION )
C
               ERXXDN(J1) = ERXXDN(J1) - F1S(1)
               ERYYDN(J1) = ERYYDN(J1) - F1S(2)
               ERZZDN(J1) = ERZZDN(J1) - F1S(3)

               ERXXDN(J2) = ERXXDN(J2) - F2S(1)
               ERYYDN(J2) = ERYYDN(J2) - F2S(2)
               ERZZDN(J2) = ERZZDN(J2) - F2S(3)
          GO TO 140
  100     CONTINUE
          IF (JST(J1) .EQ. 0) GO TO 110
          IF (DABS(DC1) .GT. 0.99) KEY=1
          IF (DABS(DC1) .LE. 0.99) KEY=3
      CALL        TRNSFM (KEY,J1,TRD,3,4)
      CALL        TRANSP (TRD,TRDT,3,4)
      CALL        MULT (TRDT,F1S,F1S4,4,3,1)
COMMENT - ACCUMULATE JOINT EQUILIBRIUM ERROR AT MEMBERS FROM JOINT
               ERXX(J1) = ERXX(J1) - F1S4(1)
               ERYY(J1) = ERYY(J1) - F1S4(2)
               ERZZ(J1) = ERZZ(J1) - F1S4(3)
               ERVV(J1) = ERVV(J1) - F1S4(4)
          IF ( ITYPE .LE. 2 ) GO TO 120
               ERXXDN(J1) = ERXXDN(J1) - F1S4(1)
               ERYYDN(J1) = ERYYDN(J1) - F1S4(2)
               ERZZDN(J1) = ERZZDN(J1) - F1S4(3)
               ERVVDN(J1) = ERVVDN(J1) - F1S4(4)
          GO TO 120
  110     CONTINUE
               ERXX(J1) = ERXX(J1) - F1S(1)
               ERYY(J1) = ERYY(J1) - F1S(2)
               ERZZ(J1) = ERZZ(J1) - F1S(3)
          IF ( ITYPE .LE. 2 ) GO TO 120
               ERXXDN(J1) = ERXXDN(J1) - F1S(1)
               ERYYDN(J1) = ERYYDN(J1) - F1S(2)
               ERZZDN(J1) = ERZZDN(J1) - F1S(3)
  120     CONTINUE
          IF (JST(J2) .EQ. 0) GO TO 130
          IF (DABS(DC1) .GT. 0.99) KEY=2
          IF (DABS(DC1) .LE. 0.99) KEY=4
      CALL        TRNSFM (KEY,J2,TRD,3,4)
      CALL        TRANSP (TRD,TRDT,3,4)
      CALL        MULT (TRDT,F2S,F2S4,4,3,1)
COMMENT - ACCUMULATE JOINT EQUILIBRIUM ERROR AT MEMBERS FROM JOINT
               ERXX(J2) = ERXX(J2) - F2S4(1)
               ERYY(J2) = ERYY(J2) - F2S4(2)
               ERZZ(J2) = ERZZ(J2) - F2S4(3)
               ERVV(J2) = ERVV(J2) - F2S4(4)
          IF ( ITYPE .LE. 2 ) GO TO 140
               ERXXDN(J2) = ERXXDN(J2) - F2S4(1)
               ERYYDN(J2) = ERYYDN(J2) - F2S4(2)
               ERZZDN(J2) = ERZZDN(J2) - F2S4(3)
               ERVVDN(J2) = ERVVDN(J2) - F2S4(4)
          GO TO 140
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130     CONTINUE
             ERXX(J2) = ERXX(J2) - F2S(1)
             ERYY(J2) = ERYY(J2) - F2S(2)
             ERZZ(J2) = ERZZ(J2) - F2S(3)
        IF ( ITYPE .LE. 2 ) GO TO 140
             ERXXDN(J2) = ERXXDN(J2) - F2S(1)
             ERYYDN(J2) = ERYYDN(J2) - F2S(2)
             ERZZDN(J2) = ERZZDN(J2) - F2S(3)
140             CONTINUE
      RETURN
      END


********************************** SUBROUTINE **********************************
      SUBROUTINE PRINT9 (AN2,NPROB,RM,RO,W,SL,L1,L3,L4,L6)
COMMENT - SUBROUTINE PRINT9 OUTPUTS MEMBER RESULTS
      IMPLICIT REAL*8 (A-H,O-Z)
      REAL*8 JTSHR,JSYES
      REAL*4 DISJT
      REAL*4 FORCEL, STRANL, BMOMNL, CURVAL, SHFORL, GAMMAL,
     2       FORCER, STRANR, BMOMNR, CURVAR, SHFORR, GAMMAR,
     3       FRMAXF, FRMAXD, FRMMOM, FRMROT, FRMSHF,FRMLTD,
     4       TOAXF,  TOAXD,  TOMOM,  TOROT,  TOSHF, TOLTD,
     5       SHMJT
      DIMENSION RM(L6,L4), RO(L6) , W(L6)
      DIMENSION AN2(11), NPROB(2)
      DIMENSION ALPHA(41)
      DIMENSION CURVAT(22), GAMMA(22), BMS(22), SHS(22)
      COMMON /BLOCK1/ X(25),        Y(25),        QXX(25),      QYY(25),
     2   QZZ(25),     SXX(25),      SYY(25),      SZZ(25),      DXX(25),
     3   DYY(25),     DZZ(25),      RXX(25),      RYY(25),      RZZ(25),
     4   ERXX(25),    ERYY(25),     ERZZ(25),     QMJ(25),      WMJ(25),
     5   NSXX(25),    NSYY(25),     NSZZ(25),     IMJ(25),      NSXP(25),
     6   NSYP(25),    ISTJB(25)
      COMMON /BALA01/ QVV(25),      SVV(25),      DVV(25),      ERVV(25),
     2   RVV(25),     NSVV(25)
      COMMON /BLOCK2/ DXS( 25),     DYS( 25),     ZLS( 25),     DC1S( 25),
     2   DC2S( 25),   PRF( 25),     PRAE( 25),    QM( 25),      WM( 25),
     3   PRAG(25),    ELEMN(25),
     4   IOPOP( 25),  IPINL( 25),   IPINR( 25),   NC51( 25),    INLOP( 25),
     5   NAL( 25),    NSXL( 25),    NSYL( 25),    NSZL( 25),    NAR( 25),
     6   NSXR( 25),   NSYR( 25),    NSZR( 25),    NCDS( 25),    IAXOPS( 25)
      COMMON /BALA02/ JST(25),NJSS(25),HLJ(25),HRJ(25),VLJ(25),VUJ(25),
     2   THKJ(25),GJ(25),SJC(25)
      COMMON /BLOCK4/ FOMM(50,6),SMC(50,21),IST(50),  LT(50),
     2   JT1(50),     JT2(50),      NITM(50),     IMM(50),      IMC(50)
      COMMON /BLOCK7/ F( 22),       AE( 22),      SX( 22),      SY( 22),
     2   SZ( 22),     QX( 22),      QY( 22),      QZ( 22),      DX( 22),
     3   DY( 22),     DZ( 22),      ERX( 22),     ERY( 22),     ERZ( 22),
     4   SQX( 22),    SQY( 22),     SQZ( 22),     U1( 22),      V1( 22),
     5   W1( 22),     U2( 22),      V2( 22),      W2( 22),      DS(3,3, 22),
     6   BM1S( 22),   BM2S( 22),    TTS( 22),     AG( 22)
      COMMON /BLOC21/ ACCJT(100),VELJT(100),ZMASSR(100),DACCJT(100),
     2   DVELJT(100),FACCJT(100),FDAMJT(100),CDAMP(100),DISJT(80,71)
      COMMON /BLK1/   TOL,   ELEMNT, NJST,   KEEP3C, NCD3C,
     2          KEEP2, KEEP3A,KEEP3B,KEEP4A,KEEP4B,KEEP4C,KEEP5A,
     3          KEEP5B,KEEP5C,KEEP5D,KEEP6, KEEP7, NCD2,  NCD3A,
     4          NCD3B, NCD4A, NCD4B, NCD4C, NCD5A, NCD5B, NCD5C,
     5          NCD5D, NCD6,  NCD7,  IP8,   IP9,   IP10,  ITYPE,
     6          IABAN, IFORM, NM,    NJT,   NST,   NLT,   M,
     7          MP1,   MP2,   ISIT,  LTT,   ITYPEL,IDJ,   NSTL
      COMMON /BLK2/ XL,XR,X1,X2,         H,TH,HSQ,HCU,X2L,I1,I2,NQ
      COMMON /BLK3/ MNJT,MNST,MNLT,MNM,MNC5,MNC6,MDJT,MNJS,MNE,MNCS,
     2   MNPCS,MNSS,MNQWM,MNJST,MNJSS
      COMMON /BLK5/ NFSUB,NITF,N1,N2
      COMMON /BLK7/ INLOPI,IFAE,KOFFJ,KOFFQW,KOFFSE
      COMMON/ITC/ ERR1,ERR2,ER1,ER2,DTI,CM,NTI,MM(20),MJ(20),MNITF,
     2      MNITM,NSMJ,NSMM
      COMMON /WARN/ NJNC,NMNC
      COMMON /SKT2/     WRX(25,10),   WRY(25,10),   WRZ(25,10),
     2    WRV(25,10),   WRXP(25,10),  WRYP(25,10),  WRTX(25,10),
     3    WRTY(25,10),  WRTZ(25,10),  WRTV(25,10),  WRTXP(25,10),
     4    WRTYP(25,10)
      COMMON /SKT5/         WRXM (21,10),  WRYM (21,10),  WRZM (21,10),
     2                      WRTXM(21,10),  WRTYM(21,10),  WRTZM(21,10)
      COMMON /SKT11/        MSSINL,        MSSIM1
      COMMON /SKT13/        EPR1S(21,10,3),EPRT1S(21,10,3),
     2                      EPR2S(21,10,3),EPRT2S(21,10,3)
      COMMON /SKT15/  JJ
      COMMON /SKT22/  TIME, JT, IRDYN, IRSTEP(71)
      COMMON /SKT25/  ITSLEF, ITSRGT, NLE, NRE
      COMMON /SKT26/  LTYPEL
      COMMON /SKT27/  IREAD,  IWRITE
      COMMON /SKT28/  FORCEL(20,71),STRANL(20,71),BMOMNL(20,71),
     2     CURVAL(20,71),FORCER(20,71),STRANR(20,71),BMOMNR(20,71),
     3     CURVAR(20,71),FRMAXF(20,71),FRMAXD(20,71),FRMMOM(20,71),
     4     FRMROT(20,71),FRMSHF(20,71),FRMLTD(20,71),TOAXF(20,71),
     5     TOAXD(20,71), TOMOM(20,71), TOROT(20,71), TOSHF(20,71),
     6     TOLTD(20,71)
      COMMON /SKT29/  EPSLON(22), CURVA1(22), CURVA2(22)
      COMMON /SKT30/  MSTIF(25), MLOAD(25), MODEL(25)
      COMMON /SKT32/  EPBF1  (21,10,3), EPBFT1(21,10,3), SLBF1  (21,10,3),
     2                SLBFT1(21,10,3), EPBF2  (21,10,3), EPBFT2(21,10,3),
     3                SLBF2  (21,10,3), SLBFT2(21,10,3),
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      4                EPSMAX(21,2,10), EPSMIN(21,2,10), EPSPRE(21,2,10),
      5                YGROW  (21,2,10), YTGROW(21,2,10)
       COMMON /CHAN1/  JTSHR
       COMMON /CHA13/  GAMRS(25,3),GAMRTS(25,3)
       CCMMON /CHA28/  SHFORL(20,71),GAMMAL(20,71),SHFORR(20,71),
      2    GAMMAR(20,71),SHMJT(20,71)
       EQUIVALENCE  (CURVAT(1),CURVA1(1)) , (GAMMA(1),CURVA2(1)) ,
      2            (BMS(1),BM1S(1)) , (SHS(1),BM2S(1))
   11  FORMAT   (   5H1        ,80X , 10HI-----TRIM  )
   16  FORMAT  (    17H        PROB (CONTD) , /5X,A4,A1,10X,A5,7A8,A4,/)
   51  FORMAT   (   30H        TABLE 9 - MEMBER RESULTS ,/ )
   52  FORMAT   (   40H        TABLE 9 - MEMBER RESULTS (CONTD)   ,/ )
   53  FORMAT  (    52H        ** LIMIT OF MEMBERS Q-W CURVE EXCEEDED ON THIS,
      2 ,           11H  PROBLEM **)
   54  FORMAT  (    44H        ** LIMIT OF MEMBERS STRESS-STRAIN CURVE,
      2             25H  EXCEEDED ON THIS PROBLEM)
   61  FORMAT   (   18H        MEMBER NUMBER,I5,15H     STIFF TYPE,I5,
      2             15H        LOAD TYPE  , I5 )
   71  FORMAT   (   14H        LENGTH =  ,E11.3, 13H     ALPHA = ,E11.3,
      2             13H         BETA =  ,E11.3 )
   81  FORMAT   (   20H        GOES FROM JOINT, I5 ,  9H TO JOINT,I5)
   91  FORMAT   (   36H        OUTPUT DISTANCES ARE FROM JOINT, I5,
      2             25H  ALONG THE MEMBER AXIS    )
   99  FORMAT (//,50H        ***  MEMBER DID NOT CONVERGE AT END OF SPECIF,
      2 28HIED NUMBER OF ITERATIONS *** )
  101  FORMAT   (   49H        ALL OUTPUT FORCES AND DISPLACEMENTS ARE WITH,
      2        30H RESPECT TO THE MEMBER AXES           ,//,
      3      26X,   15H DISPLACEMENTS , 21X,   7H FORCES,//,
      4             50H          DISTANCE     AXIAL     LATERAL   ROTATIONAL ,
      5        30H  AXIAL        SHEAR      MOMENT ,9X,8(5HIXXXX),1HI,//)
  111  FORMAT ( 5X, 7 ( 1PE11.3), 7X, 41 A1 )
  201  FORMAT   (   46H        ALL OUTPUT FORCES ARE WITH RESPECT TO THE,
      2             15H MEMBER AXES     , //, 15X,
      3             10H AT JOINT  , I5,  12X, 10H AT JOINT  , I5,//,5X,
      4             15H AXIAL FORCE =  ,E11.3,5X,  15H AXIAL FORCE =  ,E11.3,
      5      /, 5X, 15H SHEAR          = ,E11.3,5X,  15H SHEAR         = ,E11.3,
      6      /, 5X, 15H MOMENT         = ,E11.3,5X,  15H MOMENT        = ,E11.3,
      7      ///)
  210  FORMAT (///,5X,13HMEMBER NUMBER, I5)
  220  FORMAT (///,5X,13HMEMBER NUMBER,I5,10X,12HTIME STEP   ,I5,5X,
      2    4HTIME,6X,F11.6)
  230  FORMAT (///,5X,13HMEMBER LENGTH,F10.3,5X,14HNUMBER OF ELEM,I3,5X,
      2        11HELEMNT LNGTH,F10.4,//)
  240  FORMAT ( 6(/),5X,4HELEM,31X,11HFIRST HINGE,13X,12HSECOND HINGE,
      2 //,5X,    54HNUMB  AXIAL FORC  AXIAL STRAIN  BEND MOMENT  CURVATURE
      3 ,           28H      BEND MOMENT   CURVATURE,///)
  250  FORMAT ( 5X, I2, 3X, 2 ( 2 (1PE11.3), 3X), 2 (1PE11.3) )
  777  FORMAT (     48H      ***  SOLUTION DID NOT CLOSE - STUDY MONITOR,
      2             10H DATA *** )
  300  FORMAT ( 6(/),5X,4HELEM,
      2 //,5X,    54HNUMB  AXIAL FORC  AXIAL STRAIN  BEND MOMENT  CURVATURE
      3  ,       4X,25HSHEAR FORCE  SHEAR STRAIN,///)
               DATA A,B,C /1H ,1H*,1H-/
               DATA SHEAR /5HSHEAR/
               DATA JSYES /5HJSYES/
               NJMNC = NJNC + NMNC
          IF ( NJMNC .NE . 0 ) GO TO 1000
COMMENT - STORE RESULTS ON PERMANENT UNIT FOR EVERY STATIC ANALYSIS PROB
          IF ( ITYPE .LE. 2 ) GO TO 800
               NJTT = NJT * 3
          IF (JTSHR .NE. JSYES) GO TO 785
          DO 780 I = 1,NJT
          IF (JST(I) .NE. 0) NJTT = NJTT + 1
  780     CONTINUE
  785     CONTINUE
               NTI1 = NTI + 1
COMMENT - STORE RESULTS ON PERMANENT UNIT FOR THE LAST TIME STEP
          IF ( JT .EQ. NTI1 ) GO TO 800
COMMENT - STORE RESULTS ON PERMANENT UNIT EVERY 4 TH TIME STEP.
               NSTORE = 4
               TEMP = 0.0
          DO 790 I = 1,NJTT
  790          TEMP = TEMP + ZMASSR(I)
COMMENT - STORE RESULTS ON PERMANENT UNIT AT EACH TIME STEP OF
COMMENT - A PSEUDO-DYNAMIC PROBLEM WITH ALL ZERO MASS JOINTS
          IF ( TEMP .LE. 1.0E-08 ) NSTORE = 1
          IF ( (JT-1)/NSTORE*NSTORE .EQ. JT-1 ) GO TO 800
          GO TO 1000
  800     CONTINUE
      REWIND  IWRITE
          IF (JTSHR .EQ. JSYES) GO TO 910
      WRITE( IWRITE) ( DXX(I), DYY(I), DZZ(I), I=1,NJT )
          DO 900 I = 1,NJT
               NTEMP = NSXX(I) + NSYY(I) + NSZZ(I) + NSXP(I) + NSYP(I)
          IF ( NTEMP .EQ. 0 ) GO TO 900
      WRITE(IWRITE)     (WRX(I,J),WRTX(I,J),WRY(I,J),WRTY(I,J),WRZ(I,J),
      2               WRTZ(I,J),WRXP(I,J), WRTXP(I,J),WRYP(I,J),WRTYP(I,J),
      3                J = 1,10 )
  900     CONTINUE
          GO TO 950
  910     CONTINUE
      WRITE (IWRITE)  (DXX(I),DYY(I),DZZ(I),DVV(I), I=1,NJT)
      WRITE (IWRITE)  ((GAMRS(I,J),GAMRTS(I,J),J=1,3),I=1,NJT)
          DO 940 I = 1,NJT
               NTEMP = NSXX(I)+NSYY(I)+NSZZ(I)+NSVV(I)+NSXP(I)+NSYP(I)
          IF ( NTEMP .EQ. 0 ) GO TO 940
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    WRITE(IWRITE)   (WRX(I,J),WRTX(I,J),WRY(I,J),WRTY(I,J),WRZ(I,J),
   2               WRTZ(I,J),WRV(I,J),WRTV(I,J),WRXP(I,J),WRTXP(I,J),
   3               WRYP(I,J),WRTYP(I,J), J = 1,10 )
 940       CONTINUE
 950       CONTINUE
           IF ( ITYPE .LE. 2 ) GO TO 1000
     WRITE ( IWRITE ) JT, TIME, ( VELJT(I), I=1,NJTT )
     WRITE ( IWRITE) ( ACCJT(I), I=1,NJTT )
 1000      CONTINUE
              MPRINT = 0
           IF (ITYPE .LE. 2 .AND. IP9 .EQ. 0 ) MPRINT = 1
           IF ( ITYPE .LE. 2 ) GO TO 1100
           IF ( IP9 .EQ. 0 ) GO TO 1050
           IF ((JT-1)/IP9*IP9 .EQ. JT-1) MPRINT = 1
 1050      CONTINUE
           IF ( JT .EQ. NTI1 ) MPRINT = 1
 1100      CONTINUE
           DO 8500 JJ = 1,NM
              ISTT = IST(JJ)
              MODELT = MODEL(ISTT)
              INLOPT = INLOP(ISTT)
              ELEMNT = ELEMN(ISTT)
           IF ( INLOPT .EQ. 0 ) GO TO 1200
              NWRITE = NSXL(ISTT)+NSYL(ISTT)+NSZL(ISTT)
 1200      CONTINUE
              NITM(JJ) = MNITM + 1
COMMENT - SKIP IF PRINTING OF TABLE 9 IS TO BE AVOIDED
           IF ( MPRINT .NE. 1 ) GO TO 2100
COMMENT - SKIP FOR COMPLETE OUTPUT
           IF ( IOPOP(ISTT) .EQ. 0 ) GO TO 1600
           IF ( JJ .EQ. 1 )   GO TO 1500
COMMENT - PRINT PARTIAL RESULTS FOR 3 MEMBERS ON 1 SHEET
           IF ( IOPL .NE. 1 ) GO TO 1500
           IPC = IPC + 1
           IF (IPC .EQ. 4) GO TO 1500
           GO TO 2100
 1500         IPC = 1
 1600      CONTINUE
COMMENT - PRINT HEADINGS
      PRINT 11
      PRINT 16, NPROB, (AN2(II),II=1,9)
           IF ( JJ .EQ. 1 )  GO TO 1700
      PRINT  52
           GO TO 2100
 1700 PRINT  51
 2100      CONTINUE
COMMENT - SUBROUTINE MEMSOL DOES THE ITERATIVE NONLINEAR MEMBER SOLUTION
COMMENT - THIS SOLUTION IS REQUIRED TO FIND THE MEMBER-END-FORCES FOR
COMMENT - THE JOINT EQUILIBRIUM CHECK AND FOR THE FINAL MEMBER SOLUTION
      CALL      MEMSOL (   BM,RO,W,SI,L1,L3,L4,L6)
           IF ( ITYPE .GE. 3 .AND. IABAN .EQ. 1 ) GO TO 2150
           IF (NJNC .GT. 0 .OR. NMNC .GT. 0)  PRINT 777
           IF (IMC(JJ) .EQ. 1)  PRINT  99
 2150      CONTINUE
           IF ( MPRINT .NE. 1 ) GO TO 7100
           IF ( ITYPE .GE. 3 ) GO TO 2200
      PRINT 210, JJ
           GO TO 2250
 2200 PRINT 220, JJ, JT, TIME
 2250 PRINT 230, ZLS(ISTT), M, TH
 2500 PRINT 61, JJ, ISTT, LTT
      PRINT 71, ZLS(ISTT), DC1S(ISTT), DC2S(ISTT)
      PRINT  81, JT1( JJ ), JT2( JJ )
           IF ( IOPOP(ISTT) .EQ. 1 )  GO TO 5100
 2800 PRINT 91, JT1( JJ )
 3100 PRINT 101
COMMENT - PRINT COMPLETE MEMBER RESULTS
              SCALE = 0.0
           DO 3400 I = 1,MP1
              TEMP = DABS( DY(I) )
           IF ( TEMP .GT. SCALE ) SCALE = TEMP
 3400      CONTINUE
              SCALE = SCALE / 2.0
           DO 3800 I = 1,MP1
           DO 3500 II = 1, 41
 3500         ALPHA(II) = A
              ALPHA(21) = C
           IF ( SCALE .GT. 1.0D-15 ) GO TO 3600
              MTEMP = 21
           GO TO 3650
 3600      CONTINUE
              MTEMP = 10.0 * DY(I) / SCALE + 21.5
 3650      CONTINUE
              ALPHA(MTEMP) = B
           IF ( I .NE. 1 ) GO TO 3660
              DIS = 0.0
              T = -U1(2)
              V = V1(2)
              BM = -W1(2)
           GO TO 3700
 3660      CONTINUE
           IF ( I .EQ. MP1 ) GO TO 3670
              IP1 = I + 1
              DIS = DIS + TH
              T       =  0.5*(U2(I) - U1(IP1))
              V       = -0.5*(V2(I) - V1(IP1))
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                 BM     =  0.5*(W2(I) - W1(IP1))
        GO TO 3700
 3670   CONTINUE
             DIS = DIS + TH
             T = U2(MP1)
             V = -V2(MP1)
             BM = W2(MP1)
 3700   CONTINUE
     PRINT 111, DIS,DX(I),DY(I),DZ(I),T,V,BM,(ALPHA(II), II=1,41 )
 3800   CONTINUE
        IF (ELEMNT .EQ. SHEAR) GO TO 4100
     PRINT 240
        DO 4000 I = 2,MP1
     PRINT 250, I,TTS(I),EPSLON(I),BM1S(I),CURVA1(I),BM2S(I),CURVA2(I)
 4000   CONTINUE
        GO TO 4300
 4100   CONTINUE
     PRINT 300
     DO 4200 I = 2,MP1
     PRINT 250, I,TTS(I),EPSLON(I),BMS(I),CURVAT(I),SHS(I),GAMMA(I)
 4200   CONTINUE
 4300   CONTINUE
        GO TO 7100
 5100   CONTINUE
COMMENT - PRINT PARTIAL  MEMBER RESULTS
             TL    = - U1(2)
             VL    =   V1(2)
             BML    = -W1(2)
             TR      = U2(MP1)
             VR      = -V2(MP1)
             BMR       = W2(MP1)
     PRINT 201,JT1(JJ),JT2(JJ),TL,TR,VL,VR,BML,BMR
 7100   CONTINUE
             IOPL = IOPOP(ISTT)
        IF ( ITYPE .GE. 3 .AND. IABAN .EQ. 1 ) GO TO 7150
        IF (KOFFOW .EQ. 1) PRINT 53
        IF (KOFFSE .EQ. 1) PRINT 54
 7150   CONTINUE
 7200   CONTINUE
        IF ( NJMNC .NE . 0 ) GO TO 8000
        IF ( ITYPE .LE. 2 ) GO TO 7250
        IF ( JT .EQ. NTI1 ) GO TO 7250
        IF ( (JT-1)/NSTORE*NSTORE .EQ. JT-1 ) GO TO 7250
        GO TO 8000
 7250   CONTINUE
     WRITE( IWRITE) ( DX(I), DY(I), DZ(I), I=1,MP2 )
        IF ( INLOPT .EQ. 0 ) GO TO 8000
        IF ( NWRITE .EQ. 0 ) GO TO 7300
     WRITE(IWRITE) ((WRXM(I,J),WRTXM(I,J),WRYM(I,J),WRTYM(I,J),
    2             WRZM(I,J), WRTZM(I,J), J = 1, 10), I = 2,MP1 )
 7300   CONTINUE
        IF ( MODELT .LE. -1 ) GO TO 8000
        IF (ELEMNT .EQ. SHEAR) GO TO 7400
             NHINGE = 2
     WRITE(IWRITE) (((EPR1S(I,J,K),EPRT1S(I,J,K),EPR2S(I,J,K),
    2             EPRT2S(I,J,K),K = 1,MSSIM1), J=1,MNPCS), I=2,MP1 )
        IF ( MODELT .EQ. 0 ) GO TO 8000
     WRITE (IWRITE) (((EPBF1 (I,J,K), EPBFT1(I,J,K), SLBF1 (I,J,K),
    2             SLBFT1(I,J,K), EPBF2 (I,J,K), EPBFT2(I,J,K),
    3             SLBF2 (I,J,K), SLBFT2(I,J,K), K=1,MSSIM1 ),
    4             J = 1,MNPCS ), I = 2,MP1 )
        GO TO 7500
 7400   CONTINUE
             NHINGE = 1
     WRITE (IWRITE) ((( EPR1S(I,J,K), EPRT1S(I,J,K),
    2             K = 1,MSSIM1), J=1,MNPCS), I=2,MP1 )
        IF ( MODELT .EQ. 0 ) GO TO 8000
     WRITE (IWRITE) (((EPBF1 (I,J,K), EPBFT1(I,J,K), SLBF1 (I,J,K),
    2             SLBFT1(I,J,K), K=1,MSSIM1 ),J=1,MNPCS),I=2,MP1)
 7500   CONTINUE
     WRITE (IWRITE) (((EPSMAX(I,L,J), EPSMIN(I,L,J), EPSPRE(I,L,J),
    2             J = 1,MNPCS ), L = 1,NHINGE ), I = 2,MP1 )
        IF ( MODELT .NE. 2 ) GO TO 8000
     WRITE (IWRITE) (((YGROW (I,L,J), YTGROW(I,L,J), J = 1,MNPCS ),
    2             L = 1,NHINGE ), I = 2,MP1 )
 8000   CONTINUE
        IF ( ITYPE .LE. 2 ) GO TO 8500
COMMENT - IDENTIFY ALL MONITOR MEMBERS AND STORE THEIR HYSTERISIS RECORD
        IF ( JJ .NE. 1 ) GO TO 8100
             III = 0
 8100   CONTINUE
        IF ( IMM(JJ) .EQ. 0 ) GO TO 8200
             III = III + 1
             II  = III
COMMENT - THE FOLLOWING STATEMENTS STORE INFORMATION ABOUT THE SECTION
COMMENT - RESPONSE IN THE DIRECTION OF DEFORMED GEOMETRY
        IF (ELEMNT .EQ. SHEAR) GO TO 8105
             FORCEL(II,JT) = TTSLEF
        IF ( IPINL(ISTT) .EQ. 1 ) NLE = 1
             STRANL(II,JT) = EPSLON(NLE+1)
             BMOMNL(II,JT) = BM1S   (NLE+1)
             CURVAL(II,JT) = CURVA1(NLE+1)
             FORCER(II,JT) = TTSRGT
        IF ( IPINR(ISTT) .EQ. 1 ) NRE = MP2
             STRANR(II,JT) = EPSLCN(NRE-1)
             BMOMNR(II,JT) = BM2S   (NRE-1)
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                CURVAR(II,JT) = CURVA2(NRE-1)
          GO TO 8110
 8105     CONTINUE
          IF (IPINL(ISTT) .EQ. 1) NLE = 1
                FORCEL(II,JT) = TISLEF
                STRANL(II,JT) = EPSLON(NLE+1)
                BMOMNL(II,JT) = BMS   (NLE+1)
                CURVAL(II,JT) = CURVAT(NLE+1)
                SHFORL(II,JT) = SHS   (NLE+1)
                GAMMAL(II,JT) = GAMMA (NLE+1)
          IF (IPINR(ISTT) .EQ. 1) NRE = 1
                FORCER(II,JT) = TISRGT
                STRANR(II,JT) = EPSLON(NRE-1)
                BMOMNR(II,JT) = BMS   (NRE-1)
                CURVAR(II,JT) = CURVAT(NRE-1)
                SHFORR(II,JT) = SHS   (NRE-1)
                GAMMAR(II,JT) = GAMMA (NRE-1)
 8110     CONTINUE
COMMENT - THE FOLLOWING STMNTS (UPTO #8200) STORE THE INFORMATION ABOUT
COMMENT - THE MEMBER RESPONSE IN THE DIRECTION OF ORIGINAL GEOMETRY.
                FRMAXF(II,JT) = -U1(2)
                FRMAXD(II,JT) = DX(1)
                FRMSHF(II,JT) = V1(2)
                FRMLTD(II,JT) = DY(1)
                FRMMOM(II,JT) = -W1(2)
                FRMROT(II,JT) = DZ(1)
                TOAXF(II,JT) = U2(MP1)
                TOAXD(II,JT) = DX(MP1)
                TOSHF(II,JT) = -V2(MP1)
                TOLTD(II,JT) = DY(MP1)
                TOMOM(II,JT) = W2(MP1)
                TOROT(II,JT) = DZ(MP1)
 8200     CONTINUE
 8500     CONTINUE
          IF ( ITYPE .GE. 3 ) GO TO 9000
          IF ( NJMNC .NE. 0 ) GO TO 9000
      WRITE( IWRITE) (( FOMM(I,J), I=1,NM), J=1,6 )
 9000     CONTINUE
          IF ( NJMNC .NE. 0 ) GO TO 9900
          IF ( ITYPE .LE. 2 ) GO TO 9500
          IF ( JT .EQ. NTI1 ) GO TO 9500
          IF ( (JT-1)/NSTORE*NSTORE .EQ. JT-1 ) GO TO 9500
          GO TO 9900
 9500     CONTINUE
      ENDFILE  IWRITE
      REWIND 13
      WRITE(13) IWRITE
      ENDFILE 13
          IF ( IWRITE .EQ. 12 ) GO TO 9600
                IWRITE = 12
          GO TO 9900
 9600     CONTINUE
                IWRITE = 11
 9900     CONTINUE
      RETURN
      END


*********************************** SUBROUTINE **********************************
      SUBROUTINE ADDYN (JTN,FSS)
COMMENT - SUBROUTINE ADDYN, CALLED BY SUBROUTINE DYNA, ADDS THE
COMMENT - CONTRIBUTION DUE TO MASS AND DAMPING TO STIFFNESS MATRIX TO
COMMENT - OBTAIN INCREMENTAL JOINT DISPLACEMENT USING CONSTANT AVERAGE
COMMENT - ACCELERATION METHOD.
        IMPLICIT REAL*8 (A-H,O-Z)
        REAL*4 DISJT
        DIMENSION FSS(3)
        COMMON /BLOC10/ SSL(4,24)
        COMMON /BLOC21/ ACCJT(100),VELJT(100),ZMASSR(100),DACCJT(100),
     2      DVELJT(100),FACCJT(100),FDAMJT(100),CDAMP(100),DISJT(80,71)
        COMMON /BLOC23/ DFFS(4,25)
        COMMON/ITC/ ERR1,ERR2,ER1,ER2,DTI,CM,NTI,MM(20),MJ(20),MNITF,
     2          MNITM,NSMJ,NSMM
              DSS2=4.0/DTI**2
              DSS12=2.0/DTI
        DO 100 I = 1,3
              ITEMP=3*JTN-3+I
 100          SSL(I,I)=SSL(I,I)+DSS2*ZMASSR(ITEMP)
     2        +DSS12*CDAMP(ITEMP)
        DO 200 I = 1,3
 200  FSS(I) = FSS(I) + DFFS(I,JTN)
      RETURN
      END


*********************************** SUBROUTINE **********************************
      SUBROUTINE DYSTLD (FJX,FJY,FJZ,FJV,TIME,JTN)
      IMPLICIT REAL*8 (A-H,O-Z)
      DIMENSION QQ1(300), WW1(300)
      COMMON /BLOC1/ ZMASS(25),FTMJXX(25),FTMJYY(25),FTMJZZ(25),
     2     FTMJVV(25),TTMJ(25),NFTXX(25),NFTYY(25),NFTZZ(25),NFTVV(25)
      COMMON /BLK7/ INLOPT,IFAE,KOFFJ,KOFFQW,KOFFSE
```

```
     2COMMON/BLK9/ NVL(20,300),  NTJ(20,300),  NVLT(300),
                   NTJT(300),    NPTV(20),     MNPTF
                 ISYM=0
COMMENT - X - CURVE
           IF (NFTXX(JTN) .EQ. 0) GO TO 3510
                 NC = NFTXX(JTN)
                 NPTT = NPTV(NC)
           DO 3505 I = 1,NPTT
                 QQ1(I) = NVL(NC,I)
 3505            WW1(I) = NTJ(NC,I)
                 WJ = TIME / TTMJ(JTN)
        CALL CURVE1 (QQ1,WW1,WJ,NPTT,ISYM,FJX,SJX,KOFFJ)
                 FJX = FJX * FTMJXX (JTN)
           GO TO 3511
 3510      CONTINUE
                 FJX=0.0
 3511      CONTINUE
           IF (NFTYY(JTN) .EQ. 0) GO TO 3520
COMMENT - Y - CURVE
                 NC = NFTYY(JTN)
                 NPTT = NPTV(NC)
           DO 3515 I = 1,NPTT
                 QQ1(I) = NVL(NC,I)
 3515            WW1(I) = NTJ(NC,I)
                 WJ = TIME / TTMJ(JTN)
        CALL CURVE1 (QQ1,WW1,WJ,NPTT,ISYM,FJY,SJY,KOFFJ)
                 FJY = FJY * FTMJYY (JTN)
           GO TO 3521
 3520      CONTINUE
                 FJY = 0.0
 3521      CONTINUE
           IF (NFTZZ(JTN) .EQ. 0) GO TO 3530
COMMENT - Z - CURVE
                 NC = NFTZZ(JTN)
                 NPTT = NPTV(NC)
           DO 3525 I = 1,NPTT
                 QQ1(I) = NVL(NC,I)
 3525            WW1(I) = NTJ(NC,I)
                 WJ = TIME / TTMJ(JTN)
        CALL CURVE1 (QQ1,WW1,WJ,NPTT,ISYM,FJZ,SJZ,KOFFJ)
                 FJZ = FJZ * FTMJZZ (JTN)
           GO TO 3531
 3530      CONTINUE
                 FJZ=0.0
 3531      CONTINUE
           IF (NFTVV(JTN) .EQ. 0) GO TO 3540
COMMENT - V - CURVE
                 NC = NFTVV(JTN)

                 NPTT = NPTV(NC)
           DO 3535 I = 1,NPTT
                 QQ1(I) = NVL(NC,I)
 3535            WW1(I) = NTJ(NC,I)
                 WJ = TIME / TTMJ(JTN)
        CALL CURVE1 (QQ1,WW1,WJ,NPTT,ISYM,FJV,SJV,KOFFJ)
                 FJV = FJV * FTMJVV (JTN)
           GO TO 3541
 3540      CONTINUE
                 FJV = 0.0
 3541      CONTINUE
        RETURN
        END


*********************************** SUBROUTINE ***********************************
        SUBROUTINE CURVE1 ( QQ1, WW1, WJ, NPT, ISYM, QJ, S2, KOFFJ )
COMMENT - SUBROUTINE CURVE1 INTERPOLATES ALONG A DYNAMIC FORCE CURVE
        IMPLICIT REAL*8 (A-H,O-Z)
        DIMENSION QQ1(300),  WW1(300)
                 NEG = 0
           IF (ISYM .EQ. 1 .AND. WJ .LT. 0.0) GO TO 2100
           GO TO 2200
 2100      WJ = - WJ
                 NEG = 1
 2200      CONTINUE
           DO 3040 NP = 2,NPT
           IF (WJ -WW1(NP)) 3045,3055,3040
 3040      CONTINUE
                 NP = NPT
           GO TO 3050
 3045      IF (WJ -WW1(1)) 3050,3055,3055
 3050            KOFFC = 1
 3055            NP = NP - 1
                 S2 = -(QQ1(NP + 1) -QQ1(NP))/(WW1(NP+ 1) - WW1(NP))
                 QJ =QQ1(NP) - S2*(WJ -WW1(NP))
           IF (NEG .EQ. 0) GO TO 4300
                 QJ = -QJ
                 WJ = -WJ
 4300      CONTINUE
        RETURN
        END
```

```
*********************************** SUBROUTINE ***********************************
      SUBROUTINE CSPLCT (TR,KEY,I,TIME,II)
COMMENT - SUBROUTINE CSPLCT PLOTS MONITOR JOINT RESPONSE AGAINST TIME.
      IMPLICIT REAL*8 (A-H,O-Z)
      COMMON /GT/ MJO
      COMMON/ITC/ ERR1,ERR2,ER1,ER2,DTI,CM,NTI,MM(20),MJ(20),MNITF,
     2            MNITM,NSMJ,NSMM
      DIMENSION TR(71)
    1 FORMAT(1H1)
   30 FORMAT (5X,7HJOINT  ,I3,/)
   31 FORMAT (    23H RELATIVE DISP OF JOINT,I5,2H /,I5)
  100 FORMAT (2X,2HJT,2X,4HTIME,2X,12HDISPLACEMENT,1X,10(5HIXXXX),1HI,
     2  /,12X,11HX-DIRECTION,//)
  101 FORMAT (2X,2HJT,2X,4HTIME,2X,12HDISPLACEMENT,1X,10(5HIXXXX),1HI,
     2  /,12X,11HY-DIRECTION,//)
  102 FORMAT (2X,2HJT,2X,4HTIME,2X,12HROTATION    ,1X,10(5HIXXXX),1HI,
     2  /,12X,11HZ-ROTATION ,//)
  103 FORMAT (2X,2HJT,2X,4HTIME,2X,12HROTATION    ,1X,10(5HIXXXX),1HI,
     2  /,12X,11HY-ROTATION ,//)
  104 FORMAT (2X,2HJT,2X,4HTIME,2X,12HSH. MOMENT(Z),1X,10(5HIXXXX),1HI,
     2  ///)
              TIME3 = TIME - NTI * DTI
              NTI1 = NTI + 1
      PRINT 1
          IF (II .EQ. 1 .OR. KEY .EQ. 5) GO TO 250
          IF (MJO .EQ. 0) GO TO 250
          IF (MJO .EQ. 1) GO TO 240
              MJB = MJ(II-1)
          GO TO 245
  240         MJB = MJ(1)
  245 PRINT 31,I,MJB
      GO TO 251
  250 PRINT 30,I
  251     CONTINUE
          GO TO (300,400,500,600,700),KEY
  300 PRINT 100
          GO TO 1000
  400 PRINT 101
          GO TO 1000
  500 PRINT 102
          GO TO 1000
  600 PRINT 103
          GO TO 1000
  700 PRINT 104
 1000 CALL SPLOT ( TR, NTI1, 1, 1, 1, NTI1, TIME3, DTI )
      RETURN
      END

*********************************** SUBROUTINE ***********************************
      SUBROUTINE SPLOT (F,N,N1,N2,N3,N4,X1,H)
C         SUB SPLOT WILL PLOT A FUNCTION F(X) -- ALL ARGUMENTS ARE INPUT
C         F( ) = SINGLY SUBCRIPTED VARIABLE CONTAINING F(X)
C         N = TOTAL NUMBER OF POINTS IN F( )        N1 = FIRST POINT TO BE
C         N2 = INCREMENT BETWEEN PLOTTED POINTS     N3 = INCREMENT BETEEEN
C         N4 = LAST POINT TO BE PLOTTED             X1 = X VALUE OF FIRST
C         H = X DISTANCE BETWEEN POINTS IN F()
      IMPLICIT REAL*8 (A-H,O-Z)
      DIMENSION F(N), ALPHA(51)
      DATA A,B,C/1H ,1H*,1H-/
    3 FORMAT (1H )
    4 FORMAT ( ///, 10X, 15HALL VALUES ZERO)
    7 FORMAT ( I4, F8.5, 1X, 1PE12.4, 51A1 )
              X = X1
              V = 0.0
         DO 10 I = N1,N4
        Z=DABS(F(I))
   10     IF (Z .GT. V) V = Z
              VS = V / 2.5
         IF ( VS .EQ. 0.0 ) GO TO 100
              M = 1 + (N4 - N1)/N2
      DO 90 J = 1,M
              I = N1 + (J-1)*N2
              NF   = 10.0*F(I)/VS + 26.5
         DO 80 II = 1,51
              ALPHA (II) = A
         IF (II .EQ. 26 ) ALPHA(II) = C
         IF (II .EQ. NF   )    ALPHA(II) = B
   80    CONTINUE
      PRINT 7, I, X, F(I), ( ALPHA(II), II=1,51 )
              RN2 = N2
              X = X + H*RN2
         IF ( N3 .EQ. 1) GO TO 90
              N31 = N3 - 1
         DO 85  LL = 1,N31
   85 PRINT 3
   90     CONTINUE
          GO TO 105
  100 PRINT 4
  105     CONTINUE
      RETURN
      END
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 ************************************ SUBROUTINE ************************************
      SUBROUTINE DETAMS (DELA,DELM,DELS,I,D,TT,BM,SH)
COMMENT - SUBROUTINE DETAMS COMPUTES THE AVERAGE AXIAL THRUST,BENDING
COMMENT - MOMENT AND SHEAR FORCE IN AN DISCRETE ELEMENT.  AND ALSO THE
COMMENT - INCREMENTAL FORCE-DEFORMATICN MATRIX FOR AN ELEMENT WITH
COMMENT - LINEAR STRESS-STRAIN CURVE (INLOPT = 0).
      IMPLICIT REAL*8 (A-H,O-Z)
      DIMENSION D(6,6)
      DIMENSION EPSCOM(10), SIGCOM(10)
      COMMON /BLOCK2/ DXS( 25),    DYS( 25),    ZLS( 25),    DC1S( 25),
     2    DC2S( 25),   PRF( 25),    PRAE( 25),   QM( 25),     WM( 25),
     3    PRAG(25),    ELEMN(25),
     4    IOPOP( 25),  IPINL( 25),  IPINR( 25),  NC51( 25),   INLOP( 25),
     5    NAL( 25),    NSXL( 25),   NSYL( 25),   NSZL( 25),   NAR( 25),
     6    NSXR( 25),   NSYR( 25),   NSZR( 25),   NCDS( 25),   IAXOPS( 25)
      COMMON /BLOCK4/ FOMM(50,6),SMC(50,21),IST(50),     LT(50),
     2    JT1(50),     JT2(50),       NITM(50),  IMM(50),     IMC(50)
      COMMON /BLOCK7/ F( 22),      AE( 22),     SX( 22),     SY( 22),
     2    SZ( 22),     QX( 22),     QY( 22),     QZ( 22),     DX( 22),
     3    DY( 22),     DZ( 22),     ERX( 22),    ERY( 22),    ERZ( 22),
     4    SQX( 22),    SQY( 22),    SQZ( 22),    U ( 22),     V ( 22),
     5    W1( 22),     U2( 22),     V2( 22),     W2( 22),     DS(3,3, 22),
     6    BM1S( 22),   BM2S( 22),   TTS( 22),    AG( 22)
      COMMON /BALA09/ GL(10),       DGL(10),     SHCL(10),    DSHCL(10)
      COMMON /BLOCK9/ BCL(10),      DBCL(10),    DCL(10),     DDCL(10),
     2    YCL(10),     DYCL(10),    SIGL(10,11), EPSL(10,11),DSIGL(10,11),
     3    DEPSL(10,11),ISST(10),      NSSL(10),  NSSR(10)
      COMMON /BALA12/ SHC(20,10)
      COMMON /BLOC12/ SM(20,10),    EM(20,10),   BI(20,10),  DI(20,10),
     2    YI(20,10),   NSS(20,10),  NA(20),      NCDA(20),   IRECT(20,10)
      COMMON /BALA13/ GS(08)
      COMMON /BLOC13/ NPTS( 08),   ISS( 08),   NSIG(08,11),NEPS(08,11),
     2    NSIT(11),    NEPT(11)
      COMMON /BLOC15/ EPST(21),     SIGT(21),    EPSTS(11),   SIGTS(11)
      COMMON /BLK1/  TOL,    ELEMNT,NJST,  KEEP3C,NCD3C,
     2          KEEP2, KEEP3A,KEEP3B,KEEP4A,KEEP4B,KEEP4C,KEEP5A,
     3          KEEP5B,KEEP5C,KEEP5D,KEEP6, KEEP7, NCD2,  NCD3A,
     4          NCD3B, NCD4A, NCD4B, NCD4C, NCD5A, NCD5B, NCD5C,
     5          NCD5D, NCD6,  NCD7,  IP8,   IP9,   IP10,  ITYPE,
     6          IABAN, IFORM, NM,    NJT,   NST,   NLT,   M,
     7          MP1,   MP2,   ISTT,  LTT,   ITYPEL,IDJ,   NSTL
      COMMON /BLK2/ XL,XR,X1,X2,          H,TH,HSQ,HCU,X2L,I1,I2,NQ
      COMMON /BLK7/ INLOPT,IFAE,KCFFJ,KOFFQW,KOFFSE
      COMMON/ITC/ ERR1,ERR2,ER1,ER2,DTI,CM,NTI,MM(20),MJ(20),MNITF,
     2        MNITM,NSMJ,NSMM
      COMMON /SKT10/     NDIV(20,10),   NPCTOT(20)
      COMMON /SKT12/     EPSIEL(08,03), SIGMAX(08,03)
      COMMON /SKT15/ JJ

      COMMON /SKT25/ TTSLEF, TTSRGT, NLE, NRE
      COMMON /SKT31/ ALPHA (8), BETA  (8), SMLSLP(8), EPSTHD(8),
     2              SLOPHD (8), SIGULT(8), MATRL (8)
      IF (I .GT. 2) GC TO 1500
COMMENT - SKIP FOR ALL BUT FIRST ELEMENT
COMMENT - COMPUTE NUMBER CF RIGID ELEMENTS AND NUMBER OF LINEAR ELEMENTS
COMMENT - AT ENDS OF MEMBERS
            NR = - IPINL(ISTT)/10
            NE = - IPINL(ISTT) - 10*NR
            NLR = 1 + NR
            NLE = NLR + NE
            NR = - IPINR(ISTT)/10
            NE = - IPINR(ISTT) - 10*NR
            NRR = MP2 - NR
            NRE = NRR - NE
 1500 CONTINUE
      IF (INLOPT .EQ. 1) GO TC 2100
COMMENT - COMPUTE AXIAL FCRCE,MOMENT,SHEAR FORCE AND INCREMENTAL FORCE
COMMENT - DEFORMATICN MATRIX FOR ELEMENT WITH LINEAR ELASTIC CURVE
      DO 1600 J = 1,3
      DO 1600 K = 1,3
 1600       D(J,K) = 0.0
            D(1,1) = AE(I)/TH
            D(2,2) = F(I)/TH
            D(3,3) = AG(I)/TH
            TT = D(1,1)*DELA
            BM = D(2,2)*DELM
            SH = D(3,3)*DELS
      IF (I .GT. NLR .AND. I .LT. NRR) GO TO 4100
COMMENT - MULTIPLY VALUES BY 10 FCR RIGID ELEMENT
            TT = TT*10.0
            BM = BM*10.0
            SH = SH*10.0
            D(1,1) = D(1,1)*10.0
            D(2,2) = D(2,2)*10.0
            D(3,3) = D(3,3)*10.0
      GO TO 4100
 2100 CONTINUE
      IF (I .GT. 2) GC TO 2500
COMMENT - SKIP FOR ALL BUT FIRST ELEMENT
COMMENT - COMPUTE SECTICN PROPERTIES AT MEMBERS
COMMENT - FROM JOINT AND DIFFERENCE IN THESE PROPERTIES BETWEEN FROM AND
COMMENT - TO JOINTS
            NALT = NAL(ISTT)
            NART = NAR(ISTT)
            NCDAT = NCDA(NALT)
      DO 2200  J = 1,NCDAT
            BCL(J) = BI(NALT,J)
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            DBCL(J) = (BI(NART,J) - BCL(J))/M
            DCL(J) = DI(NALT,J)
            DDCL(J) = (DI(NART,J) - DCL(J))/M
            YCL(J) = YI(NALT,J)
            DYCL(J) = (YI(NART,J) - YCL(J))/M
            NSSL(J) = NSS(NALT,J)
            NSSLT = NSSL(J)
            NSSRT = NSS(NART,J)
            SHCL(J) = SHC(NALT,J)
            DSHCL(J) = (SHC(NART,J) - SHCL(J))/M
            GL(J) = GS(NSSLT)
            DGL(J) = (GS(NSSRT) - GS(NSSLT))/M
COMMENT - IF SIG-EP CURVE IS NON-LINEAR BUT ELASTIC, THEN COMPUTE
COMMENT - STRESS-STRAIN CURVE AT MEMBERS FROM JOINT AND DIFFERENCE
COMMENT - IN THESE PROPERTIES BETWEEN FROM AND TO JOINTS
COMMENT - IF SIG-EP CURVE IS NON-LINEAR AND INELASTIC, THEN THESE
COMMENT - STEPS NEED NOT BE DONE SINCE THE CURVES INCLUDING THE
COMMENT - TWO MULTIPLIERS MUST BE SAME AT THE FROM AND TO JOINTS
      IF ( NDIV(NALT,J) .NE. 0 ) GO TO 2200
            NSSR(J) = NSS(NART,J)
            NSSRT = NSSR(J)
            NPTST = NPTS(NSSLT)
            ISST(J) = ISS(NSSLT)
      DO 2180 K = 1,NPTST
            SIGL(J,K) = NSIG(NSSLT,K)*SM (NALT,J)
            SIGR = NSIG(NSSRT,K)*SM(NART,J)
            EPSL(J,K) = NEPS(NSSLT,K)*EM(NALT,J)
            EPSR = NEPS(NSSRT,K)*EM(NART,J)
            DSIGL(J,K) = (SIGL(J,K) - SIGR)/M
            DEPSL(J,K) = (EPSL(J,K) - EPSR)/M
 2180 CONTINUE
 2200 CONTINUE
 2500 CONTINUE
COMMENT - (IR = 1) FOR RIGID ELEMENT
COMMENT - (IE = 1) FOR LINEAR ELEMENT
            IR = 0
            IE = 0
      IF (I .LE. NLR) IR = 1
      IF (I .LE. NLE) IE = 1
      IF (I .GE. NRR) IR = 1
      IF (I .GE. NRE) IE = 1
            ZMUL = I - 2
            ZMUL = ZMUL + 0.5
COMMENT - COMPUTE DEFORMATIONS IN ELEMENT
            EPA = DELA/TH
            EPS = DELS/TH
            CUR = DELM/TH
COMMENT - ZERO ELEMENT THRUST, BENDING MOMENTS, AND STIFFNESS TERMS
            BM1 = 0.0
            TT1 = 0.0
            SH1 = 0.0
            EI1 = 0.0
            AE1 = 0.0
            AG1 = 0.0
            AEY1 = 0.0
            D(1,3) = 0.0
            D(2,3) = 0.0
            D(3,1) =0.0
            D(3,2) = 0.0
COMMENT - INITIALISE THE PARAMETER THAT IS USED TO KEEP TRACK
COMMENT - OF THE (PRESCRIBED) SUBDIVIDED PIECES AND THEIR CUMULATIVE
COMMENT - POSITION ( APPLICABLE FOR INELASTIC CASE ONLY )
            ICUMU = 0
      DO 4000  J = 1, NCDAT
COMMENT - COMPUTE SECTION PROPERTIES AT MID-ELEMENT
            B = BCL(J) + ZMUL*DBCL(J)
            DP = DCL(J) + ZMUL*DDCL(J)
            Y = YCL(J) + ZMUL*DYCL(J)
            NSSLT = NSSL(J)
            NPTST = NPTS(NSSLT)
COMMENT - COMPUTE SHEAR MODULUS AND SHEAR COEFFICIENT AT MID-ELEMENT
            SHCOEF = SHCL(J) + ZMUL*DSHCL(J)
            G = GL(J) + ZMUL*DGL(J)
COMMENT - COMPUTE STRESS-STRAIN CURVE AT MID-ELEMENT ONLY FOR THE
COMMENT - NON-LINEAR ELASTIC CASE.
COMMENT - IF IT IS THE INELASTIC CASE , THEN THE SIG-EP CURVE AT
COMMENT - MID-ELEMENT IS THE SAME AS THAT AT THE FROM OR TO JOINT.
      IF ( NDIV(NALT,J) .EQ. 0 ) GO TO 2590
            NPTSM1 = NPTST - 1
      DO 2560 K = 1,NPTSM1
            SIGCOM(K) = SIGMAX(NSSLT,K) * SM(NALT,J)
            EPSCOM(K) = EPSIEL(NSSLT,K) * EM(NALT,J)
 2560 CONTINUE
COMMENT - THE ABOVE DO-LOOP CONTAINS COMPUTATIONS FOR THE INDIVIDUAL
COMMENT - COMPONENT SIG-EPS CURVES
COMMENT - NOW ALSO COMPUTE THE MAXIMUM SLOPE AT THE ORIGIN OF THE
COMMENT - VIRGIN SIG-EPS CURVE FOR USE IN STRAIN REVERSAL CHECK CASE
            SMSCL = SM(NALT,J)
            EMSCL = EM(NALT,J)
            SIGMA = NSIG(NSSLT,2) * SMSCL
            PSLON = NEPS(NSSLT,2) * EMSCL
            SLPMAX = SIGMA / PSLON
COMMENT - COMPUTE THE SMALL SLOPE FROM YLD PT, EPSILON STRAIN HARDENING,
COMMENT - SLOPE STRAIN HARDENING, ULTIMATE STRESS, ALPHA AND BETA FACTOR
COMMENT - (FOR MILD STEEL )
COMMENT - IF IT IS NOT MILD STEEL, THEN THESE VALUES HAVE BEEN
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COMMENT - PROPERLY ASSIGNED IN SUBROUTINE  SECUR.
                  SMALL  = SMLSLP(NSSLT) * SMSCL / EMSCL
                  EPHD   = EPSTHD(NSSLT) * EMSCL
                  SLHD   = SLOPHD(NSSLT) * SMSCL / EMSCL
                  SULT   = SIGULT(NSSLT) * SMSCL
                  ALP    = ALPHA  (NSSLT)
                  BET    = BETA   (NSSLT)
        GO TO 3910
 2590 CONTINUE
            DO 2600  K = 1,NPTST
                  EPSTS(K) = EPSL(J,K)  + ZMUL*DEPSL(J,K)
 2600             SIGTS(K) = SIGL(J,K)  + ZMUL*DSIGL(J,K)
            IF (ISST (J)  .EQ.  1)  GO TO 2650
            DO 2610 K = 1, NPTST
                  EPST(K)  = EPSTS(K)
                  SIGT(K)  = SIGTS(K)
 2610       CONTINUE
                  ISSTT = 0
                  NPT = NPTST
            GO TO 2700
 2650             EPST(NPTST)  = EPSTS(1)
                  SIGT(NPTST)  = SIGTS(1)
            DO 2675  K = 2,NPTST
                  KR = K + NPTST - 1
                  KL = KR - 2* (K - 1)
                  EPST(KR)  =   EPSTS(K)
                  EPST(KL)  = -EPSTS(K)
                  SIGT(KR)  = SIGTS(K)
 2675             SIGT(KL)  = -SIGTS(K)
                  NPT = 2* (NPTST) - 1
                  ISSTT = 1
 2700       CONTINUE
COMMENT - SUBDIVIDE PIPE PIECE INTO TEN EQUIVALENT RECTANGLES. (TWENTY
COMMENT - EQUAL RADIAL SEGMENTS WITH SEGMENTS IN OPPOSITE SIDES OF Y
COMMENT - AXIS COMBINED)
                  NPP = 1
            IF (IRECT(NALT,J)  .EQ.  1)  NPP = 10
COMMENT - DO FOR EACH RECTANGLE IN PIECE
            DO 3900 IP = 1,NPP
            IF (NPP .EQ. 10) CALL PIPE (B,DP,Y,IP,NPP)
COMMENT - CALL FAEJR TO COMPUTE AXIAL THRUST, BENDING MOMENT AND
COMMENT - STIFFNESS TERMS FOR ONE RECTANGLE AT LOCATION OF FIRST
COMMENT - DISCRETE SPRING IN ELEMENT
      CALL        FAEJR (TT,BM,EA,EI,AEY,ISSTT,NPT,Y,B,DP,EPA,CUR,IR,IE,
     2                   SH,GA,EPS,ELEMNT,SHCOEF,G)
COMMENT - ACCUMULATE VALUES FOR ALL RECTANGLES
                  TT1 = TT1 + TT
                  BM1 = BM1 + BM

                  SH1 = SH1 + SH
                  EI1 = EI1 + EI
                  AEY1 = AEY1 + AEY
                  AE1 = AE1 + EA
                  AG1 = AG1 + GA
 3900       CONTINUE
        GO TO 4000
 3910 CONTINUE
COMMENT - INITIALISE THE FOLLOWING ADDITIONAL TERMS USED IN THE
COMMENT - INELASTIC CASE
                  TT  = 0.0
                  BM = 0.0
                  EA = 0.0
                  AEY= 0.0
                  EI = 0.0
COMMENT - DO FOR EACH OF THE EQUALLY SUBDIVIDED RECTANGULAR PIECES
COMMENT - OF THE SINGLE INPUT J TH RECTANGLE ( OR PIPE IF APPLICABLE )
                  NJ = NDIV(NALT,J)
            DO 3950 IJ = 1,NJ
                  ICUMU = ICUMU + 1
            IF ( IRECT(NALT,J)  .EQ.  1 )  GO TO 3920
COMMENT - SUBDIVIDE THE J TH PIECE AND SUPPLY B,DP,Y FOR EACH SUB-PIECE
                  AIJ = IJ
                  IF  ( IJ .NE.  1 )  GO TO 3918
                  ANJ = NJ
                  DDP = DP / ANJ
                  YC1 = Y + DP * 0.5 - DDP * 0.5
                  DP = DDP
 3918 Y = YC1 - ( AIJ - 1.0 ) * DP
        GO TO 3930
 3920 CALL        PIPE ( B, DP, Y, IJ, NJ )
 3930 CONTINUE
COMMENT - IF ALPHA=BETA=0, GO TO MASING SUBROUTINE
            IF ( ALPHA(NSSLT)+BETA(NSSLT)  .LT.  1.0D-10 )  GO TO 3935
COMMENT - IF ALPHA#0, BETA=0  OR  ALPHA#BETA#0 , GO TO DEGRADATION CUM
COMMENT - YIELD GROWTH MODEL.
      CALL        DEGROW (SIGHIS,STFHIS,Y,EPA,CUR,CUR2,IR,IE,
     2                   SIGCOM,EPSCOM,NPTSM1,ICUMU,I,SLPMAX,
     3                   SMALL,EPHD,SLHD,SULT,ALP,BET )
            GO TO 3938
 3935       CONTINUE
COMMENT - SUBROUTINE MASING EVALUATES THE HISTORY DEPENDENT
COMMENT - STRESS AND STIFFNESS, FOR THE SUB-PIECE AT THE LOCATION
COMMENT - OF BOTH THE HINGES 1&2, ACCORDING TO MASING PATH
      CALL        MASING (SIGHIS,STFHIS,Y,EPA,CUR,CUR2,IR,IE,
     2                   SIGCOM,EPSCOM,NPTSM1,ICUMU,I,SLPMAX )
 3938       CONTINUE
                  TT  = TT   + SIGHIS
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              BM  = BM  + SIGHIS * Y
              EA  = EA  + STFHIS
              AEY = AEY + STFHIS * Y
              EI  = EI  + STFHIS * Y * Y
 3950 CONTINUE
              BDP = B * DP
              TT  =  TT   *  BDP
              BM  =  BM  *(-BDP)
              EA  =  EA  *  BDP
              AEY =  AEY *  BDP
              EI  =  EI  *  BDP
              GA = G*SHCOEF*BDP*NJ
              SH = GA*EPS
              TT1 = TT1 + TT
              BM1 = BM1 + BM
              SH1 = SH1 + SH
              EI1 = EI1 + EI
              AEY1 = AEY1 + AEY
              AE1 = AE1 + EA
              AG1 = AG1 +GA
 4000     CONTINUE
COMMENT - SAVE AE1 AND AG1
              AE(I) = AE1
              AG(I) = AG1
              TT = TT1
              BM = BM1
              SH = SH1
COMMENT - COMPUTE INCREMENTAL FORCE DEFORMATION MATRIX FOR ELEMENT
              D(1,1) = AE1/TH
              D(2,2) = EI1/TH
              D(3,3) = AG1/TH
              D(1,2) = -AEY1/TH
              D(2,1) = D(1,2)
 4100     CONTINUE
COMMENT - STORE TT OF THE FIRST & LAST NONLINEAR ELEMENTS FOR LATER
COMMENT - USE IN SUBROUTINE PRINT9,WHERE THE HYSTERISIS OF MONITOR
COMMENT - MEMBERS ARE RECORDED
          IF ( NITM(JJ) .NE. MNITM + 2 ) GO TO 4300
          IF ( INLOPT .EQ. 1 ) GO TO 4150
          IF ( I .NE. 2 ) GO TO 4120
              TTSLEF = TT
          GO TO 4300
 4120     CONTINUE
          IF ( I .NE. MP1 ) GO TO 4300
              TTSRGT = TT
          GO TO 4300
 4150     CONTINUE
          IF ( IPINL(ISTT) .NE. 1 ) GO TO 4160
          IF ( I .NE. 2 ) GO TO 4200
              TTSLEF = TT
          GO TO 4300
 4160     CONTINUE
          IF ( I .NE. NLE + 1 ) GO TO 4200
              TTSLEF = TT
          GO TO 4300
 4200     CONTINUE
          IF ( IPINR(ISTT) .NE. 1 ) GC TO 4260
          IF ( I .NE. MP1 ) GO TO 4300
              TTSRGT = TT
          GO TO 4300
 4260     CONTINUE
          IF ( I .NE. NRE - 1 ) GC TO 4300
              TTSRGT = TT
 4300     CONTINUE
      RETURN
      END


*********************************** SUBROUTINE ************************************
      SUBROUTINE FSUB23 ( RM, RO, L6, L4, IHB )
COMMENT - SUBROUTINE FSUB23 FURNISHES RIGHT SIDE OF SYMMETRIC STIFFNESS
COMMENT - MATRIX RM AND LOAD MATRIX RO FOR THE JOINT SHEAR OPTION CASE
      IMPLICIT REAL*8 (A-H,O-Z)
      DIMENSION RM(L6,L4),RO(L6)
      DIMENSION SMM(3,3),SMS(3,3),DC(3,3),DCT(3,3),T33(3,3),
     2 FMM(3),FMS(3),FSS(4),SMS4(4,4),FMS4(4),T43(4,4),TRD(4,4),
     3 TRDT(4,4),TRO(4,4),SMS3(4,4)
      COMMON /BLOCK1/ X(25),        Y(25),       QXX(25),     QYY(25),
     2     QZZ(25),     SXX(25),     SYY(25),     SZZ(25),     DXX(25),
     3     DYY(25),     DZZ(25),     RXX(25),     RYY(25),     RZZ(25),
     4     ERXX(25),    ERYY(25),    ERZZ(25),    QMJ(25),     WMJ(25),
     5     NSXX(25),    NSYY(25),    NSZZ(25),    IMJ(25),     NSXP(25),
     6     NSYP(25),    ISTJR(25)
      COMMON /BALA01/ QVV(25),      SVV(25),     DVV(25),     ERVV(25),
     2     RVV(25),     NSVV(25)
      COMMON /BLOCK2/ DXS( 25),     DYS( 25),    ZLS( 25),    DC1S( 25),
     2     DC2S( 25),   PRF( 25),    PRAE( 25),   QM( 25),     WM( 25),
     3     PRAG(25),    ELEMN(25),
     4     IOPOP( 25),  IPINL( 25),  IPINR( 25),  NC51( 25),   INLOP( 25),
     5     NAL( 25),    NSXL( 25),   NSYL( 25),   NSZL( 25),   NAR( 25),
     6     NSXR( 25),   NSYR( 25),   NSZR( 25),   NCDS( 25),   IAXOPS( 25)
      COMMON /BALA02/ JST(25),NJSS(25),HLJ(25),HRJ(25),VLJ(25),VUJ(25),
     2     THKJ(25),GJ(25),SJC(25)
      COMMON /BLOCK3/ DXL( 25),     DYL( 25),    ZLL( 25),    DC1L( 25),
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  2     DC2L( 25),   UQX( 25),    UQY( 25),    NCDL( 25),   IAXOPL( 25),
  3     NC61( 25),   IOVRM(25)
     COMMON /BLOCK4/  FOMM(50,6),SMC(50,21),IST(50),     LT(50),
  2     JT1(50),      JT2(50),         NITM(50),    IMM(50),     IMC(50)
     COMMON /BLOC10/  SSL(4,24)
     COMMON /BLK1/   TOL,     ELEMNT,NJST,   KEEP3C,NCD3C,
  2             KEEP2,  KEEP3A,KEEP3B,KEEP4A,KEEP4B,KEEP4C,KEEP5A,
  3             KEEP5B,KEEP5C,KEEP5D,KEEP6,  KEEP7,  NCD2,   NCD3A,
  4             NCD3B,  NCD4A,  NCD4B,  NCD4C,  NCD5A,  NCD5B,  NCD5C,
  5             NCD5D,  NCD6,   NCD7,   IP8,    IP9,    IP10,   ITYPE,
  6             IABAN,  IFORM,  NM,     NJT,    NST,    NLT,    M,
  7             MP1,    MP2,    ISTT,   LTT,    ITYPEL,IDJ,     NSTL
     COMMON /BLK5/ NFSUB,NITP,N1,N2
     COMMON /  RI  /  NL,  ML,  J1
     COMMON /NIT/  APROB
     COMMON /SKT14 /  IRV(21,2,10),                      FOMOLD(50,6),
  2                   IRVRSE,          ITAPE,            N3
     COMMON /SKT16/        ERXXOL(25),ERYYOL(25),ERZZOL(25),ERVVOL(25)
 4750 FORMAT (  1X,  10(1PE13.5)  )
        DATA PRINT /4HRINT/
              NL4 = NL
              ML4 = ML
        DO 8000 JTN=1,NJT
        IF (JTN .NE.  1 )   GO TO 1300
COMMENT - SET CONSTANTS ON FIRST CALL FROM GRIP2A
              J1=1
              IHBP1 = IHB + 1
              IHB1 = IHB - 1
              IHB2 = IHB1 - 1
              DC(1,3)  = 0.0
              DC(2,3)  = 0.0
              DC(3,1)  = 0.0
              DC(3,2)  = 0.0
              DCT(1,3)  = 0.0
              DCT(2,3)  = 0.0
              DCT(3,1)  = 0.0
              DCT(3,2)  = 0.0
              DC(3,3)  = 1.0
              DCT(3,3)  = 1.0
 1300   CONTINUE
COMMENT - ZERO SSL AND FSS
        DO 1400 I = 1, 4
              FSS(I)  = 0.0
        DO 1400 J = 1,IHBP1
 1400         SSL(I,J)  = 0.0
COMMENT - DO FOR EACH MEMBER - ADD ITS STIFFNESS MATRIX AND LOAD MATRIX
COMMENT - INTO STRUCTURE STIFFNESS MATRIX SSL AND LOAD MATRIX FSS
        DO 3500  JJ = 1,NM
        IF   ( JT1(JJ)  .NE.  JTN .AND.  JT2(JJ)  .NE.  JTN )   GO TO 3500
              ISTT = IST(JJ)
COMMENT - SKIP FOR NULL MEMBER
        IF  ( ISTT .EQ.  0 )  GO TO 3500
COMMENT - FORM TRANSFORMATION MATRIX AND ITS TRANSPOSE
              DC(1,1)  = DC1S(ISTT)
              DC(1,2)  = DC2S(ISTT)
              DC(2,1)  = - DC(1,2)
              DC(2,2)  = DC(1,1)
              DCT(1,1)  = DC(1,1)
              DCT(1,2)  = DC(2,1)
              DCT(2,1)  = DC(1,2)
              DCT(2,2)  = DC(2,2)
        IF  (DABS(DC1S(ISTT))  .GT.  0.99)  KEYDET=1
        IF  (DABS(DC1S(ISTT))  .LE.  0.99)  KEYDET=2
        IF  (  JT2(JJ)  .EQ.  JTN )  GO TO 2300
COMMENT - FORM SMM FOR MEMBER WITH FROM JOINT AT JOINT JTN
        IF  (KEYDET  .EQ.  1)  KEY=1
        IF  (KEYDET  .EQ.  2)  KEY=3
     CALL        TRNSFM  (KEY,JTN,TRD,ID1,ID2)
              SMM(1,1)  = SMC(JJ,1)
              SMM(1,2)  = SMC(JJ,2)
              SMM(1,3)  = SMC(JJ,3)
              SMM(2,1)  = SMC(JJ,2)
              SMM(2,2)  = SMC(JJ,7)
              SMM(2,3)  = SMC(JJ,8)
              SMM(3,1)  = SMC(JJ,3)
              SMM(3,2)  = SMC(JJ,8)
              SMM(3,3)  = SMC(JJ,12)
COMMENT - FORM FMM FOR MEMBER WITH FROM JOINT AT JOINT JTN
 2250         FMM(1)  =   FOMM(JJ,1)
              FMM(2)  =   FOMM(JJ,2)
              FMM(3)  =   FOMM(JJ,3)
        GO TO 2500
 2300   CONTINUE
COMMENT - FORM SMM FOR MEMBER WITH  TO  JOINT AT JOINT JTN
        IF  (KEYDET  .EQ.  1)  KEY=2
        IF  (KEYDET  .EQ.  2)  KEY=4
     CALL        TRNSFM  (KEY,JTN,TRD,ID1,ID2)
              SMM(1,1)  = SMC(JJ,16)
              SMM(1,2)  = SMC(JJ,17)
              SMM(1,3)  = SMC(JJ,18)
              SMM(2,1)  = SMC(JJ,17)
              SMM(2,2)  = SMC(JJ,19)
              SMM(2,3)  = SMC(JJ,20)
              SMM(3,1)  = SMC(JJ,18)
              SMM(3,2)  = SMC(JJ,20)
              SMM(3,3)  = SMC(JJ,21)
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COMMENT - FORM FMM FOR MEMBER WITH  TO  JOINT AT JOINT JTN
 2350           FMM(1) =  FOMM(JJ,4)
                FMM(2) =  FOMM(JJ,5)
                FMM(3) =  FOMM(JJ,6)
 2500     CONTINUE
COMMENT - TRANSFORM SMM AND FMM TO STRUCTURE COORDINATES SMS AND FMS
       CALL MATM33  ( DCT, SMM, T33)
       CALL MATM33  ( T33, DC,  SMS)
 2550  CALL MATM31  ( DCT, FMM, FMS)
COMMENT - TRANSFORM 3-DEGREE OF FREEDOM SMS AND FMS INTO 4-DEGREE
COMMENT- SMS4 AND FMS4
          DO 2560 I=1,3
          DO 2560 J=1,3
 2560           SMS3(I,J) = SMS(I,J)
      CALL          TRANSP (TRD,TRDT,ID1,ID2)
      CALL          MULT  (TRDT,SMS3,T43,ID2,ID1,ID1)
      CALL          MULT  (T43,TRD,SMS4,ID2,ID1,ID2)
      CALL          MULT  (TRDT,FMS,FMS4,ID2,ID1,1)
COMMENT - ADD (SUBTRACT) IN FMS4 TO STRUCTURE LOAD MATRIX FSS
COMMENT - ADD IN SMS4 TO DIAGONAL SUBMATRIX OF SSL - SYMMETRICAL TERMS
          DO 2600 I=1,ID2
                FSS(I) = FSS(I) - FMS4(I)
          DO 2600 J=I,ID2
                SSL(I,J) = SSL(I,J) + SMS4(I,J)
 2600     CONTINUE
COMMENT - SKIP FOR SMM WHICH ARE TO LEFT OF DIAGONAL
          IF ( JTN .GE. JT1(JJ) .AND. JTN .GE. JT2(JJ) ) GO TO 3500
          IF ( JT2(JJ) .EQ. JTN ) GO TO 2700
COMMENT - FORM SMM FOR MEMBER WITH FROM JOINT AT JOINT JTN
          IF (KEYDET .EQ. 1) KEY=2
          IF (KEYDET .EQ. 2) KEY=4
                JTNT = JT2(JJ)
      CALL          TRNSFM  (KEY,JTNT,TRO,ID1,ID3)
                SMM(1,1) = SMC(JJ,4)
                SMM(1,2) = SMC(JJ,5)
                SMM(1,3) = SMC(JJ,6)
                SMM(2,1) = SMC(JJ,9)
                SMM(2,2) = SMC(JJ,10)
                SMM(2,3) = SMC(JJ,11)
                SMM(3,1) = SMC(JJ,13)
                SMM(3,2) = SMC(JJ,14)
                SMM(3,3) = SMC(JJ,15)
                GO TO 3000
 2700     CONTINUE
COMMENT - FORM SMM FOR MEMBER WITH  TO  JOINT AT JOINT JTN
          IF (KEYDET .EQ. 1) KEY=1
          IF (KEYDET .EQ. 2) KEY=3
                JTNT = JT1(JJ)
      CALL          TRNSFM  (KEY,JTNT,TRO,ID1,ID3)
                SMM(1,1) = SMC(JJ,4)
                SMM(1,2) = SMC(JJ,9)
                SMM(1,3) = SMC(JJ,13)
                SMM(2,1) = SMC(JJ,5)
                SMM(2,2) = SMC(JJ,10)
                SMM(2,3) = SMC(JJ,14)
                SMM(3,1) = SMC(JJ,6)
                SMM(3,2) = SMC(JJ,11)
                SMM(3,3) = SMC(JJ,15)
 3000     CONTINUE
COMMENT - TRANSFORM SMM TO STRUCTURE COORDINATES SMS
      CALL          MATM33  ( DCT, SMM, T33 )
      CALL          MATM33  ( T33, DC, SMS )
          DO 3010 I=1,3
          DO 3010 J=1,3
 3010           SMS3(I,J) =SMS(I,J)
      CALL          MULT  (TRDT,SMS3,T43,ID2,ID1,ID1)
      CALL          MULT  (T43,TRO,SMS4,ID2,ID1,ID3)
COMMENT - PLACE SMS IN SSL
                JTL = JT2(JJ)
                JTS = JT1(JJ)
          IF (JTL .GT. JTS) GO TO 3100
                JTL = JT1(JJ)
                JTS = JT2(JJ)
 3100     CONTINUE
                J21 = JTL -JTS
                JTLM1 = JTL -1
                ISTP = 3*J21 + 1
          DO 3150 I = JTS,JTLM1
          IF (JST(I) .NE. 0) ISTP=ISTP + 1
 3150     CONTINUE
          DO 3200 I=1,ID2
          DO 3200 J=1,ID3
                SSL(I,ISTP+J-1) = SMS4(I,J)
 3200     CONTINUE
 3500     CONTINUE
COMMENT - CALL INELST TO FIND SPRING RESISTIVE FORCES AND TANGENT STIFF
COMMENT - NESSES  - SPRING FORCES ARE ADDED INTO LOAD MATRIX ONLY ON
COMMENT - FIRST ITERATION FROM A ZERO DISPLACEMENT START
      CALL          INELST (JTN,SJX,SJY,SJZ,SJV,SJXY,QJX,QJY,QJZ,QJV)
COMMENT - ADD IN JOINT LOADS
          IF (JST(JTN) .NE. 0) GO TO 5500
          IF (NITF .EQ. 1 .AND. ITYPE .EQ. 1) GO TO 3550
                QJX = 0.0
                QJY = 0.0
                QJZ = 0.0
 3550     CONTINUE
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      IF ( IRVRSE .NE. 0 ) GO TO 3580
COMMENT - STORE FOR USE IF REVERSAL OCCURS LATER
            ERXXCL(JTN) = ERXX  (JTN)
            ERYYCL(JTN) = ERYY  (JTN)
            ERZZCL(JTN) = ERZZ  (JTN)
      GO TO 3590
 3580 CONTINUE
            ERXX  (JTN) = ERXXCL(JTN)
            ERYY  (JTN) = ERYYCL(JTN)
            ERZZ  (JTN) = ERZZCL(JTN)
 3590 CONTINUE
            FSS(1) = FSS(1) + ERXX(JTN) + QJX
            FSS(2) = FSS(2) + ERYY(JTN) + QJY
            FSS(3) = FSS(3) + ERZZ(JTN) + QJZ
COMMENT - ADD IN JOINT RESTRAINTS
            SSL(1,1) = SSL(1,1) + SXX(JTN) + SJX
            SSL(1,2) = SSL(1,2) + SJXY
            SSL(2,2) = SSL(2,2) + SYY(JTN) + SJY
            SSL(3,3) = SSL(3,3) + SZZ(JTN) + SJZ
      IF (ITYPE .GE. 3) CALL ADDYN2(JTN,FSS)
COMMENT - SHIFT SSL TO FACILITATE OBTAINING SU FROM 2ND AND 3RD ROW
COMMENT - OF SSL
      DO 3600  I = 1,IHB
 3600       SSL(2,I) = SSL(2, I + 1)
      DO 3700  I = 1,IHB1
 3700       SSL(3,I) = SSL(3,I + 2)
            SSL(2,IHBP1) = 0.0
            SSL(3,IHBP1) = 0.0
            SSL(3,IHB)   = 0.0
 4000 CONTINUE
      DO 4500 II=1,3
      IF(SSL(II,1) .NE. 0.0) GO TO 4500
COMMENT - ZERO ON DIAGONAL MATRIX - DISPLACEMENT UNDEFINED - SET
COMMENT - DISPLACEMENT EQUAL TO 1.0E40
            SSL(II,1) = 1.0
            FSS(II) = 1.0E40
 4500 CONTINUE
      IF (APROB .NE. PRINT) GO TO 5000
COMMENT - DUMP OF STRUCTURE STIFFNESS AND LOAD MATRIX, TO ACTIVATE SET
COMMENT - LAST FIVE COLUMNS IN PROBLEM NUMBER CARD EQUAL TO PRINT
      DO 4700 II=1,3
      PRINT 4750, (SSL(II,I) ,I=1,IHBP1) ,FSS(II)
 4700 CONTINUE
 5000 CONTINUE
            J1P1 = J1 + 1
            J1P2 = J1 + 2
      IF (ML .EQ. -1) GO TO 5200
      DO 5100 J2=1,IHBP1

            RM(J1,J2)   = SSL(1,J2)
            RM(J1P1,J2) = SSL(2,J2)
            RM(J1P2,J2) = SSL(3,J2)
 5100 CONTINUE
 5200       RO(J1)   = FSS(1)
            RO(J1P1) = FSS(2)
            RO(J1P2) = FSS(3)
            J1 = J1 + 3
      GO TO 8000
 5500 CONTINUE
      IF (NITF .EQ. 1 .AND. ITYPE .EQ. 1) GO TO 5550
            QJX = 0.0
            QJY = 0.0
            QJZ = 0.0
            QJV = 0.0
 5550 CONTINUE
COMMENT - CALL SUBROUTINE DJSTSM TO OBTAIN JOINT TANGENT STIFFNESS
      CALL        DJSTSM (JTN,STFJ,SHMOJ)
      IF ( IRVRSE .NE. 0 ) GO TO 5580
COMMENT - STORE FOR USE IF REVERSAL OCCURS LATER
            ERXXCL(JTN) = ERXX  (JTN)
            ERYYCL(JTN) = ERYY  (JTN)
            ERZZCL(JTN) = ERZZ  (JTN)
            ERVVCL(JTN) = ERVV  (JTN)
      GO TO 5590
 5580 CONTINUE
            ERXX  (JTN) = ERXXCL(JTN)
            ERYY  (JTN) = ERYYCL(JTN)
            ERZZ  (JTN) = ERZZCL(JTN)
            ERVV  (JTN) = ERVVCL(JTN)
 5590 CONTINUE
            FSS(1) = FSS(1) + ERXX(JTN) + QJX
            FSS(2) = FSS(2) + ERYY(JTN) + QJY
            FSS(3) = FSS(3) + ERZZ(JTN) + QJZ
            FSS(4) = FSS(4) + ERVV(JTN) + QJV
COMMENT - ADD IN JOINT RESTRAINTS
            SSL(1,1) = SSL(1,1) + SXX(JTN) + SJX
            SSL(1,2) = SSL(1,2) + SJXY
            SSL(2,2) = SSL(2,2) + SYY(JTN) + SJY
            SSL(3,3) = SSL(3,3) + SZZ(JTN) + SJZ
            SSL(4,4) = SSL(4,4) + SVV(JTN) + SJV
COMMENT - ADD JOINT STIFFNESS TERMS
            SSL(3,3) = SSL(3,3) + STFJ
            SSL(3,4) = SSL(3,4) - STFJ
            SSL(4,4) = SSL(4,4) + STFJ
      IF (ITYPE .GE. 3) CALL ADDYN2(JTN,FSS)
COMMENT - SHIFT SSL TO FACILITATE OBTAINING RC FROM 2ND, 3RD AND 4TH
COMMENT - ROWS OF SSL.
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        DO 5600  I = 1,IHB
 5600         SSL(2,I) = SSL(2,I+1)
              DO 5700 I =1,IHB1
 5700         SSL(3,I) = SSL(3,I+2)
              DO 5800 I = 1,IHB2
 5800         SSL(4,I) = SSL(4,I+3)
              SSL(2,IHBP1) = 0.0
              SSL(3,IHBP1) = 0.0
              SSL(3,IHB)   = 0.0
              SSL(4,IHBP1) = 0.0
              SSL(4,IHB)   = 0.0
              SSL(4,IHB1)  = 0.0
        DO 6500 II=1,4
        IF(SSL(II,1) .NE. 0.0) GO TO 6500
COMMENT - ZERO ON DIAGONAL MATRIX - DISPLACEMENT UNDEFINED - SET
COMMENT - DISPLACEMENT EQUAL TO 1.0E40
              SSL(II,1) = 1.0
              FSS(II) = 1.0E40
 6500   CONTINUE
        IF (APROB .NE. PRINT) GO TO 7000
COMMENT - DUMP OF STRUCTURE STIFFNESS AND LOAD MATRIX, TO ACTIVATE SET
COMMENT - LAST FIVE COLUMNS IN PROBLEM NUMBER CARD EQUAL TO PRINT
        DO 6700 II=1,4
        PRINT 4750, (SSL(II,I),I=1,IHBP1),FSS(II)
 6700   CONTINUE
 7000   CONTINUE
              J1P1 = J1 + 1
              J1P2 = J1 + 2
              J1P3 = J1 + 3
        IF (ML .EQ. -1) GO TO 7200
        DO 7100 J2=1,IHBP1
              RM(J1,J2)   = SSL(1,J2)
              RM(J1P1,J2) = SSL(2,J2)
              RM(J1P2,J2) = SSL(3,J2)
              RM(J1P3,J2) = SSL(4,J2)
 7100   CONTINUE
 7200         RO(J1)   = FSS(1)
              RO(J1P1) = FSS(2)
              RO(J1P2) = FSS(3)
              RO(J1P3) = FSS(4)
              J1 = J1 + 4
        GO TO 8000
 8000   CONTINUE
      RETURN
      END


************************************ SUBROUTINE **********************************
      SUBROUTINE TRNSFM (KEY,JTN,TRM,ID1,ID2)
COMMENT - SUBROUTINE TRNSFM PROVIDES THE MATRIX THAT TRANSFORMS MEMBER
COMMENT - STIFFNESS AND LOAD MATRICES IN 3-DEGREE STRUCTURE COORDINATES
COMMENT - TO 4-DEGREE STRUCTURE COORDINATE SYSTEM
      IMPLICIT REAL*8 (A-H,O-Z)
      DIMENSION TRM(4,4)
      COMMON /BLOCK1/ X(25),      Y(25),      QXX(25),    QYY(25),
     2   QZZ(25),     SXX(25),    SYY(25),    SZZ(25),    DXX(25),
     3   DYY(25),     DZZ(25),    RXX(25),    RYY(25),    RZZ(25),
     4   ERXX(25),    ERYY(25),   ERZZ(25),   QMJ(25),    WMJ(25),
     5   NSXX(25),    NSYY(25),   NSZZ(25),   IMJ(25),    NSXP(25),
     6   NSYP(25),    ISTJR(25)
      COMMON /BALA01/ QVV(25),    SVV(25),    DVV(25),    ERVV(25),
     2   NSVV(25)
      COMMON /BALA02/ JST(25),NJSS(25),HLJ(25),HRJ(25),VLJ(25),VUJ(25),
     2   THKJ(25),GJ(25),SJC(25)
      COMMON /SKT23/ PDELTA
              DATA PDNO /4HPDNO/, PDN/4H PDN/
              JSTT = JST(JTN)
              ID1 = 3
        IF (JSTT .EQ. 0) GO TO 700
              ID2 = 4
        DO 200 I=1,3
        DO 200 J=1,4
              TRM(I,J) = 0.0
  200   CONTINUE
              TRM(1,1) = 1.0
              TRM(2,2) = 1.0
        IF (PDELTA .NE. PDNO .AND. PDELTA .NE. PDN) GO TO 1000
        GO TO (300,400,500,600),KEY
  300   CONTINUE
COMMENT - HORIZONTAL MEMBER WITH JOINT ON THE LEFT
              TRM(2,3) = HRJ(JSTT)
              TRM(3,4) = 1.0
        GO TO 2000
  400   CONTINUE
COMMENT - HORIZONTAL MEMBER WITH JOINT ON THE RIGHT
              TRM(2,3) = -HLJ(JSTT)
              TRM(3,4) = 1.0
        GO TO 2000
  500   CONTINUE
COMMENT - VERTICL MEMBER WITH JOINT ON THE BOTTOM
              TRM(1,4) = -VUJ(JSTT)
              TRM(3,3) = 1.0
        GO TO 2000
  600   CONTINUE
COMMENT - VERTICAL MEMBER WITH JOINT ON THE TOP
```

```
         TRM(1,4) = VLJ(JSTT)
         TRM(3,3) = 1.0
      GO TO 2000
 700  CONTINUE
         ID2 = 3
      DO 800 I=1,3
      DO 800 J=1,3
         TRM(I,J) = 0.0
 800  CONTINUE
      DO 900 I=1,3
         TRM(I,I) = 1.0
 900  CONTINUE
      GO TO 2000
1000  CONTINUE
      GO TO (1300,1400,1500,1600),KEY
1300  CONTINUE
COMMENT - HORIZONTAL MEMBER WITH JOINT ON THE LEFT
         TRM(1,3) = -HRJ(JSTT)*DSIN(DZZ(JTN))
         TRM(2,3) =  HRJ(JSTT)*DCOS(DZZ(JTN))
         TRM(3,4) = 1.0
      GO TO 2000
1400  CONTINUE
COMMENT - HORIZONTAL MEMBER WITH JOINT ON THE RIGHT
         TRM(1,3) =  HLJ(JSTT)*DSIN(DZZ(JTN))
         TRM(2,3) = -HLJ(JSTT)*DCOS(DZZ(JTN))
         TRM(3,4) = 1.0
      GO TO 2000
1500  CONTINUE
COMMENT - VERTICL MEMBER WITH JOINT ON THE BOTTOM
         TRM(1,4) = -VUJ(JSTT)*DCOS(DVV(JTN))
         TRM(2,4) = -VUJ(JSTT)*DSIN(DVV(JTN))
         TRM(3,3) = 1.0
      GO TO 2000
1600  CONTINUE
COMMENT - VERTICAL MEMBER WITH JOINT ON THE TOP
         TRM(1,4) = VLJ(JSTT)*DCOS(DVV(JTN))
         TRM(2,4) = VLJ(JSTT)*DSIN(DVV(JTN))
         TRM(3,3) = 1.0
2000  CONTINUE
      RETURN
      END
```

```
*********************************** SUBROUTINE ***********************************
      SUBROUTINE DJSTSM (JTN,STFJ,SHMOJ)
COMMENT - SUBROUTINT DJSTSM DETERMINES THE SHEAR MOMENT COUPLE AND ONE
COMMENT - STIFFNESS ELEMENT WHICH IS REQUIRED TO FORM STIFFNESS MATRIX
COMMENT - FOR EACH JOINT. IT CALLS SUBROUTINE JNTMAS TO KEEP TRACK OF
COMMENT - THE DEFORMATION HISTORY.
      IMPLICIT REAL*8 (A-H,O-Z)
      DIMENSION GAMCOM(03),TAUCOM(03)
      COMMON /BLOCK1/ X(25),        Y(25),        QXX(25),      QYY(25),
     2    QZZ(25),      SXX(25),      SYY(25),      SZZ(25),      DXX(25),
     3    DYY(25),      DZZ(25),      RXX(25),      RYY(25),      RZZ(25),
     4    ERXX(25),     ERYY(25),     ERZZ(25),     QMJ(25),      WMJ(25),
     5    NSXX(25),     NSYY(25),     NSZZ(25),     IMJ(25),      NSXP(25),
     6    NSYP(25),     ISTJR(25)
      COMMON /BALA01/ QVV(25),      SVV(25),      DVV(25),      ERVV(25),
     2    RVV(25),      NSVV(25)
      COMMON /BALA02/ JST(25),NJSS(25),HLJ(25),HRJ(25),VLJ(25),VUJ(25),
     2    THKJ(25),GJ(25),SJC(25)
      COMMON / NIT/ APROB
      COMMON /CHA13/ NPTJ( 08),    JSS( 08),    NTAU(08,08),NGAM(08,08),
     2    NTAT(08),     NGAT(08),TAUMLT(08),GAMMLT(08)
      COMMON /CHA12/     GAMIEL(08,03), TAUMAX(08,03)
      DATA PRINT /4HRINT/
  100 FORMAT (/,5X,6HJOINT=,I3,5X,13HSH.STIFFNESS=,1PE13.5,5X,
     210HSH.MOMENT=,1PE13.5,/)
         JSTT = JST(JTN)
      IF (NJSS(JSTT) .EQ. 0) GO TO 1100
         NC = NJSS(JSTT)
         NPTM1 = NPTJ(NC) - 1
      DO 1000 K = 1,NPTM1
         TAUCOM(K) = TAUMAX(NC,K)*TAUMLT(NC)
         GAMCOM(K) = GAMIEL(NC,K)*GAMMLT(NC)
 1000 CONTINUE
         SLPMAX = TAUMLT(NC)*NTAU(NC,2)/GAMMLT(NC)/NGAM(NC,2)
      CALL JNTMAS (TAUHIS,STFHIS,TAUCOM,GAMCOM,NPTM1,JTN,SLPMAX)
      GO TO 1200
 1100 CONTINUE
         STFHIS = GJ(JSTT)
         TAUHIS = STFHIS*(DZZ(JTN) - DVV(JTN))
 1200 CONTINUE
         STFJ = STFHIS*SJC(JSTT)
         SHMOJ = TAUHIS*SJC(JSTT)
      IF (APROB .NE. PRINT) GO TO 1300
      PRINT 100, JTN,STFJ,SHMOJ
 1300 CONTINUE
      RETURN
      END
```

```
 ************************************ SUBROUTINE ************************************
      SUBROUTINE MULT (AA,BB,CC,ID1,ID2,ID3)
COMMENT - SUBROUTINE MULT WILL MULTIPLY A ID1XID2 MATRIX AA TIMES A
COMMENT - ID2XID3 MATRIX BB TO OBTAIN A ID1*ID3 MATRIX CC
      IMPLICIT REAL*8 (A-H,O-Z)
      DIMENSION AA(4,4),BB(4,4),CC(4,4)
          DO 10 I = 1,ID1
          DO 10 J = 1,ID3
              CC(I,J) = 0.0
          DO 10 K = 1,ID2
   10         CC(I,J) = CC(I,J) + AA(I,K) * BB(K,J)
      RETURN
      END

 ************************************ SUBROUTINE ************************************
      SUBROUTINE TRANSP (AA,BB,ID1,ID2)
COMMENT - SUBROUTINE TRANSP WILL TRANSPOSE AN ID1XID2 MATRIX A INTO A
COMMENT - ID2*ID1 MATRIX BB
      IMPLICIT REAL*8 (A-H,O-Z)
      DIMENSION AA(4,4),BB(4,4)
          DO 10 I = 1,ID1
          DO 10 J = 1,ID2
   10         BB(J,I) = AA(I,J)
      RETURN
      END

 ************************************ SUBROUTINE ************************************
      SUBROUTINE TGCUR ( NC, IABAN )
COMMENT - SUBROUTINE TGCUR DEALS WITH THE DECOMPOSITION OF THE
COMMENT - BASIC INPUT INTEGER CURVE NUMBER NC .
COMMENT - (FOR THE SPECIAL CASE OF MILD STEEL, ONLY ONE COMPONENT IS
COMMENT - USED, TOGETHER WITH THE FEATURES OF VIRGIN STRAIN HARDENING
COMMENT - DEGRADATION, AND YIELD GROWTH)
COMMENT - PROPER SCALE FACTORS ARE TAKEN CARE OF IN SUBROUTINE  DETAMS
COMMENT - THREE TYPES OF INELASTIC STRESS-STRAIN CURVES ARE POSSIBLE
COMMENT - MASING MODEL                 ( ALPHJ = 0 , BETJ = 0 )
COMMENT - MASING WITH DEGRADATION      ( ALPHJ # 0 , BETJ = 0 )
COMMENT - SPECIAL FOR MILD STEEL       ( ALPHJ # 0 , BETJ # 0 )
COMMENT - FOR THE PRESENT, INELASTIC CASE IS RESTRICTED TO SYMMETRIC
C         CURVES WITH THE NUMBER OF INPUT POINTS LESS THAN OR EQUAL TO
C         4 ( = MSSINL ) INCLUDING ORIGIN (0,0)
COMMENT - DESCENDING BRANCHES ARE NOT CONSIDERED AND HENCE MUST NOT
C         BE INPUT
COMMENT - NO LIMIT IS PUT ON MAXIMUM STRAIN
      IMPLICIT REAL * 8 (A-H , O-Z)
      DIMENSION QQ(08), WW(08), RMAX(07)
      COMMON /CHA13/ NPTJ( 08),    JSS( 08),   NTAU(08,08),NGAM(08,08),
     2    NTAT(08),    NGAT(08),TAUMLT(08),GAMMLT(08)
      COMMON /CHA12/      GAMIEL(08,03), TAUMAX(08,03)
      COMMON /CHA31/ ALPHJ (8), BETJ  (8), SMLSLJ(8), GASTHD(8),
     2               SLPHDJ(8), TAUULT(8), MATRJ (8)
    2 FORMAT ( 10X, 4 ( F11.4, 4X ) )
    9 FORMAT ( / )
   90 FORMAT (10X,37HDETAILS OF BASIC STRESS-STRAIN CURVES,/,10X,
     2          24HSCALING FACTORS EXCLUDED,/)
  100 FORMAT (10X,14HCURVE NUMBER =,I4,5X,25H # OF COMPONENT SPRINGS =,
     2 I4)
  102 FORMAT (10X, 9H  STRAINS,6X,9H STRESSES,6X,12HSTIFFNESS OF,3X,
     2  13HMAX STRESS OF,/,
     3  10X,5HINPUT,10X,5HINPUT,10X,10HCOMPONENTS,8X,10HCOMPONENTS,/,
     4  10X,10H(INTEGERS),4X,10H(INTEGERS),5X,10H(UNSCALED),6X,
     5      10H(UNSCALED),/)
  103 FORMAT (//,5X,  25HDEGRADATION  YIELD GROWTH,/,
     2          9X,    5HALPHJ,8X,4HBETJ,//,5X,2(F10.4 ,3X),//)
  104 FORMAT (//,5X,43HDEGRADATION DEGRADATION  YIELD GROWTH YIELD,
     2 7H GROWTH,  49H SMALJ SLOPE    GAMMA          SLOPE      ULTIMATE,
     3/,9X,5HALPHJ,8X,5HALPHJ,8X,4HBETJ,9X,4HBETJ,6X,11HFROM YLD PT,
     4 36H  STRAIN HRD   STRAIN HRD     STRESS,/,
     5  8X, 47H(INPUT)      (COMPUTED)       (INPUT)      (COMPUTED),/)
  105 FORMAT (//,5X,2(F10.4,9X,1H-,6X), 4(F10.4,3X),//)
  106 FORMAT (//,5X,F10.4,9X,1H-,12X,1H-,6X,5(F10.4,3X),//)
  107 FORMAT (//,11X,1H-,6X,2(F10.4,3X),6X,1H-,6X,4(F10.4,3X),/)
  108 FORMAT (//,11X,1H-,6X,F10.4,9X,1H-,6X,5(F10.4,3X),//)
  120 FORMAT (//,36H ERROR IN INPUT OF TAU-GAMMA CURVE #,I3,/,
     2 47H BETJ FACTOR MUST = 0 UNLESS MATERIAL IS "MILD")
  122 FORMAT (//,36H ERROR IN INPUT OF TAU-GAMMA CURVE #,I3,/,
     2 59H DEGRADATION ALGORITHM (ALPHJ # 0) DEFINED ONLY IF CURVE IS,
     3 20H CONTINUOUSLY CONVEX,/,20H (EXCEPT FOR "MILD"))
  124 FORMAT (//,25H **** WARNING FOR CURVE #,I3,5H ****,/,
     2 61H MASING MODEL WITH CURVE NOT CONTINUOUSLY CONVEX IS PERMITTED,
     3 14H AT USERS RISK )
  126 FORMAT (//,36H ERROR IN INPUT OF TAU-GAMMA CURVE #,I3,/,
     2 40H 4 POINTS MUST BE USED FOR "MILD" CURVE )
  130 FORMAT (//,5X,28H ALPHJ MUST BE BETWEEN 0 & 1 )
  132 FORMAT (//,5X,34H****WARNING : ALPHJ SEEMS HIGH****,//)
  134 FORMAT (//,5X,18H BETJ MUST BE > 0 )
  136 FORMAT (//,5X,37H***WARNING : BETJ SEEMS VERY HIGH****,//)
  138 FORMAT (//,5X,47HSLOPE FOLLOWING YIELD POINT MUST BE EITHER ZERO,
     2 47H OR A NOMINALLY SMALL POSITIVE VALUE FOR "MILD",//)
                DATA MILD /4HMILD/
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```
            NAGAIN = 0
 180      CONTINUE
            NPT = NPTJ(NC)
          DO 190 J = 1,NPT
            QQ (J) = NTAU (NC,J)
            WW (J) = NGAM (NC,J)
 190      CONTINUE
            NPTM2 = NPT - 2
            NPTM1 = NPT - 1
          IF ( NPTM2 .EQ. 0 ) GO TO 205
          DO 200 J = 1,NPTM2
            SLOK=(QQ(J+1)-QQ(J))/(WW(J+1)-WW(J))
            SLOKP1=(QQ(J+2)-QQ(J+1))/(WW(J+2)-WW(J+1))
            STF  =SLOK - SLOKP1
            RMAX(J)=WW(J+1) * STF
 200 CONTINUE
 205 CONTINUE
            STF           =  (QQ(NPT)-QQ(NPTM1))/(WW(NPT)-WW(NPTM1) )
            RMAX(NPTM1)= WW(NPT) * STF
          IF ( MATRJ(NC) .EQ. MILD ) GO TO 400
          IF ( BETJ (NC) .LT. 1.0D-10) GO TO 300
             IABAN = 1
      PRINT 120, NC
          GO TO 1000
 300      CONTINUE
          DO 350 J = 1,NPTM1
          IF ( RMAX(J) .GE. 0.0 ) GO TO 350
          GO TO 370
 350      CONTINUE
          GO TO 390
 370      CONTINUE
          IF ( ALPHJ (NC) .LT. 1.0D-10 ) GO TO 380
             IABAN = 1
      PRINT 122, NC
          GO TO 1000
 380      CONTINUE
      PRINT 124, NC
 390      CONTINUE
            SMLSLJ(NC) = 0.0
            GASTHD(NC) = 10000.0 * WW(2)
            SLPHDJ(NC) = 0.0
            TAUULT(NC) = QQ(NPT)
          GO TO 500
 400      CONTINUE
          IF ( NPT .EQ. 4 ) GC TO 410
          IF ( NAGAIN .EQ. 1 ) GO TO 500
             IABAN = 1
      PRINT 126, NC
          GO TO 1000
 410      CONTINUE
            NTEMPA = 1
            NTEMPB = 1
          IF ( ALPHJ (NC) .GT. 1.0D-10 ) GO TO 420
COMMENT - IF ALPHJ IS NOT INPUT FOR MILD(STEEL), USE A REASONABLE VALUE
            ALPHJ (NC) = 0.1
            NTEMPA = 0
 420      CONTINUE
          IF ( BETJ  (NC) .GT. 1.0D-10 ) GO TO 440
COMMENT - IF BETJ  IS NOT INPUT FOR MILD(STEEL), THEN IT IS TAKEN
COMMENT - AS ZERO. HOWEVER IT IS CUTPUT UNDER THE 'COMPUTED' TITLE.
            BETJ(NC) = 0.0
            NTEMPB = 0
 440      CONTINUE
            SMLSLJ(NC) = ( QQ(3)-QQ(2) ) / ( WW(3)-WW(2) )
            GASTHD(NC) = WW(3)
            SLPHDJ(NC) = ( QQ(4)-QQ(3) ) / ( WW(4)-WW(3) )
            TAUULT(NC) = QQ(4)
            NPTJ  (NC) = 2
            NAGAIN     = 1
          GO TO 180
 500      CONTINUE
      PRINT 9
      PRINT 90
      PRINT 100, NC, NPTM1
      PRINT 9
      PRINT 102
      PRINT 2, WW(1), QQ(1)
          DO 800 J = 2,NPT
            STF = RMAX(J-1) / WW(J)
      PRINT 2, WW(J), QQ(J), STF, RMAX(J-1)
 800      CONTINUE
          DO 900 J = 1,NPTM1
COMMENT - GAMIEL(NC,J) AND TAUMAX(NC,J) PERTAIN TO THE JTH COMPONENT
C         OF THE BASIC INTEGER INPUT CURVE NUMBER  NC
            GAMIEL ( NC,J) =    WW(J+1)
            TAUMAX (NC,J) = RMAX(J)
 900      CONTINUE
          IF ( MATRJ (NC) .EQ. MILD ) GO TO 950
      PRINT 103, ALPHJ(NC), BETJ(NC)
          GO TO 982
 950      CONTINUE
      PRINT 104
          IF ( NTEMPA + NTEMPb .EQ. 0 )              GO TO 980
          IF ( NTEMPA .EQ. 0 .AND. NTEMPB .NE. 0 ) GO TC 970
          IF ( NTEMPA .NE. 0 .AND. NTEMPB .EQ. 0 ) GC TO 960
      PRINT 105, ALPHJ(NC),BETJ(NC),SMLSLJ(NC),GASTHD(NC),SLPHDJ(NC),
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    2           TAUULT(NC)
          GO TO 982
  960 PRINT 106, ALPHJ(NC),BETJ(NC),SMLSLJ(NC),GASTHD(NC),SLPHDJ(NC),
    2           TAUULT(NC)
          GO TO 982
  970 PRINT 107, ALPHJ(NC),BETJ(NC),SMLSLJ(NC),GASTHD(NC),SLPHDJ(NC),
    2           TAUULT(NC)
          GO TO 982
  980 PRINT 108, ALPHJ(NC),BETJ(NC),SMLSLJ(NC),GASTHD(NC),SLPHDJ(NC),
    2           TAUULT(NC)
  982     CONTINUE
          IF ( ALPHJ(NC) .GE. 0.0 .AND. ALPHJ(NC) .LE. 1.0 ) GO TO 984
                IABAN = 1
      PRINT 130
          GO TO 1000
  984     CONTINUE
          IF ( MATRJ(NC) .NE. MILD ) GO TO 985
          IF ( ALPHJ(NC) .LT. 0.35) GO TO 985
      PRINT 132
  985     CONTINUE
          IF ( BETJ(NC) .GE. 0.0 ) GO TO 986
                IABAN = 1
      PRINT 134
          GO TO 1000
  986     CONTINUE
          IF ( MATRJ(NC) .NE. MILD ) GO TO 987
          IF ( BETJ(NC) .LE. 0.8 ) GO TO 987
      PRINT 136
  987     CONTINUE
          IF ( SMLSLJ(NC) .GE. 0.0 ) GO TO 1000
                IABAN = 1
      PRINT 138
 1000     CONTINUE
      RETURN
      END


 *********************************** SUBROUTINE ********************************
      SUBROUTINE JNTMAS (TAUHIS,STFHIS,TAUCOM,GAMCOM,NPTM1,JTN,SLPMAX)
COMMENT - SUBROUTINE  JNTMAS  DETERMINES THE HISTORY DEPENDENT SHEAR
C         STRESS TAUHIS, AND SHEAR STIFFNESS STFHIS, AT THE JOINT JTN
      IMPLICIT REAL * 8 (A-H , O-Z)
      DIMENSION GAMCOM(03), TAUCOM(03)
      COMMON /BLOCK1/ X(25),       Y(25),       QXX(25),     QYY(25),
    2     QZZ(25),     SXX(25),     SYY(25),     SZZ(25),     DXX(25),
    3     DYY(25),     DZZ(25),     RXX(25),     RYY(25),     RZZ(25),
    4     ERXX(25),    ERYY(25),    ERZZ(25),    QMJ(25),     WMJ(25),
    5     NSXX(25),    NSYY(25),    NSZZ(25),    IMJ(25),     NSXP(25),
    6     NSYP(25),    ISTJR(25)
      COMMON /BALA01/ QVV(25),     SVV(25),     DVV(25),     ERVV(25),
    2     RVV(25),     NSVV(25)
      COMMON /BLK1/  TOL,   ELEMNT,NJST,  KEEP3C,NCD3C,
    2          KEEP2, KEEP3A,KEEP3B,KEEP4A,KEEP4B,KEEP4C,KEEP5A,
    3          KEEP5B,KEEP5C,KEEP5D,KEEP6, KEEP7, NCD2,  NCD3A,
    4          NCD3B, NCD4A, NCD4B, NCD4C, NCD5A, NCD5B, NCD5C,
    5          NCD5D, NCD6,  NCD7,  IP8,   IP9,   IP10,  ITYPE,
    6          IABAN, IFORM, NM,    NJT,   NST,   NLT,   M,
    7          MP1,   MP2,   ISTT,  LTT,   ITYPEL,IDJ,   NSTL
      COMMON /BLK5/ NFSUB,NITF,N1,N2
      COMMON /SKT3/ NCOUNT, NITERF
      COMMON /SKT6/       NITERM(50), INDEX
      COMMON /SKT14 / IRV(21,2,10),                   FOMCLD(50,6),
    2                 IRVRSE,        ITAPE,           N3
      COMMON /SKT18/ NCHECK
      COMMON /SKT22/ TIME, JT, IRDYN, IRSTEP(71)
      COMMON /CHA13/ GAMRS(25,3),GAMRTS(25,3)
      COMMON /CHA19/ JRV(25),JRGICN(25)
   25 FORMAT ( 17H **NOTE** JOINT =,I4,/,12H STRAIN     =,1PE10.3,/,
    2 12H TAUHIS    =,1PE10.3,/,12H STFHIS    =,1PE10.3)
            STRAIN = DZZ(JTN) - DVV(JTN)
            TAUHIS = 0.0
            STFHIS  = 0.0
         IF (INDEX .NE. 1) GO TO 410
         DO 400 K = 1,NPTM1
            GAMRS(JTN,K) = GAMRTS(JTN,K)
  400    CONTINUE
  410    CONTINUE
         DO 1200 K = 1,NPTM1
            SLOPE = TAUCOM(K) / GAMCOM(K)
            ER  = GAMRS (JTN,K)
            ERT = GAMRTS(JTN,K)
         IF ( DABS (STRAIN-ER) .GE. (GAMCOM(K)-5.0D-10) ) GO TO 500
C                            LINEAR ZONE ( BEGIN )
            STFHIS = STFHIS + SLOPE
            S0     = SLOPE *(STRAIN-ER)
         IF ( NCHECK .NE. 1 ) GO TO 450
COMMENT - ONLY FIRST COMPONENT NEED TO BE MONITORED FOR REVERSAL.
         IF ( K      .NE. 1 ) GO TO 450
         IF ( JRGICN(JTN) .EQ. 0 ) GO TO 450
            JRV  (JTN) = 1
         GO TO 2200
  450    CONTINUE
COMMENT - DURING ITERATION PROCESS IT IS POSSIBLE THAT THE STRAIN
COMMENT - RIDES INTO PLASTIC RANGE, AND THEN COMES INTO THE ELASTIC
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COMMENT - RANGE. IN SUCH A CASE, THE TEMPORARY RESIDUAL STRAIN MUST BE
COMMENT - PROPERLY RE-FIXED IN VALUE, SO THAT IMPROPER VALUES ARE NOT
COMMENT - ERRONEOUSLY USED IN THE NEXT PROBLEM.
COMMENT - HENCE THE FOLLOWING STATEMENT
                ERT = ER
          IF ( INDEX .EQ. 1 ) GO TO 1000
          IF ( K     .NE. 1 ) GO TO 1000
                JRGICN(JTN) =  0
C                              LINEAR ZONE ( END )
          GO TO 1000
  500 CONTINUE
          IF ( STRAIN .GT. ER ) GO TO 600
C                          NEGATIVE YIELD ZONE ( BEGIN )
                SO   = -TAUCOM(K)
          IF ( NCHECK .NE. 1 ) GO TO 550
          IF ( K      .NE. 1 ) GO TO 550
          IF ( JRGICN(JTN) .NE. 1 ) GO TO 550
                JRV (JTN) = 1
          GO TO 2200
  550     CONTINUE
                ERT =  STRAIN + GAMCOM(K)
          IF ( INDEX .EQ. 1 ) GO TO 1000
          IF ( K     .NE. 1 ) GO TO 1000
                JRGICN(JTN) = -1
C                          NEGATIVE YIELD ZONE ( END )
      GO TO 1000
C                          POSITIVE YIELD ZONE ( BEGIN )
  600           SO   = TAUCOM(K)
          IF ( NCHECK .NE. 1 ) GO TO 650
          IF ( K      .NE. 1 ) GO TO 650
          IF ( JRGICN(JTN) .NE. -1) GO TO 650
                JRV (JTN) = 1
          GO TO 2200
  650     CONTINUE
                ERT = STRAIN - GAMCOM(K)
          IF ( INDEX .EQ. 1 ) GO TO 1000
          IF ( K     .NE. 1 ) GO TO 1000
                JRGICN(JTN) = +1
C                          POSITIVE YIELD ZONE ( END )
 1000           TAUHIS = TAUHIS + SO
                GAMRS (JTN,K) = ER
                GAMRIS(JTN,K) = ERT
 1200 CONTINUE
          IF ( ITYPE .LE. 2 ) GO TO 2050
          IF ( IRDYN .EQ. 1 .AND. NITERF .EQ. 2) GO TO 2100
          GO TO 2200
 2050     CONTINUE
          IF (NITF .EQ. 2 .AND. NITERF .EQ. 2 ) GO TO 2100
          GO TO 2200
 2100     CONTINUE
          IF ( JRV(JTN) .EQ. 0 ) GO TO 2200
                STFHIS = SLPMAX
                JRV(JTN) = 0
 2200     CONTINUE
COMMENT - OUTPUT MESSAGE IF SHEAR STRAIN EXCEEDS THE LAST STRAIN
COMMENT - ORDINATE OF VIRGIN CURVE
          IF (DABS(STRAIN) .LT. GAMCOM(NPTM1) ) GO TO 2500
          IF ( NPTM1 .EQ. 1 ) GO TO 2500
      PRINT 25, JTN,STRAIN,TAUHIS,STFHIS
 2500     CONTINUE
          IF (NCHECK .EQ. 1) IRVRSE = IRVRSE + JRV(JTN)
      RETURN
      END


*********************************** SUBROUTINE ***********************************
      SUBROUTINE DYNAJS (RM, RO, W, SL, L1, L3, L4, L6, DELWJT )
COMMENT - SUBROUTINE DYNAJS PERFORMS DYNAMIC ANALYSIS FOR FRAMES THAT
COMMENT - INCLUDE JOINT SHEAR DEFORMATION EFFECTS.
      IMPLICIT REAL*8 (A-H,O-Z)
      REAL*8 MEMBER
      REAL*4 DISJT
      REAL*4 FORCEL, STRANL, BMOMNL, CURVAL, SHFORL, GAMMAL,
     2       FORCER, STRANR, BMOMNR, CURVAR, SHFORR, GAMMAR,
     3       FRMAXF, FRMAXD, FRMMCM, FRMROT, FRMSHF,FRMLTD,
     4       TOAXF,  TOAXD,  TOMOM,  TOROT,  TOSHF, TOLTD,
     5       SHMJT
      REAL*4 FOMTEM
      DIMENSION SMMT(21)
      DIMENSION FOMT(6)
      DIMENSION FOMTEM(50,6)
      DIMENSION TR(71)
      DIMENSION RM(L6,L4), RO(L6), W(L6)
      DIMENSION DELWJT (L6)
      COMMON /BLOCK1/ X(25),        Y(25),        QXX(25),      QYY(25),
     2     QZZ(25),     SXX(25),      SYY(25),      SZZ(25),      DXX(25),
     3     DYY(25),     DZZ(25),      RXX(25),      RYY(25),      RZZ(25),
     4     ERXX(25),    ERYY(25),     ERZZ(25),     QMJ(25),      WMJ(25),
     5     NSXX(25),    NSYY(25),     NSZZ(25),     IMJ(25),      NSXP(25),
     6     NSYP(25),    ISTJR(25)
      COMMON /BALA01/ QVV(25),      SVV(25),      DVV(25),      ERVV(25),
     2     RVV(25),     NSVV(25)
      COMMON /BLOCK2/ DXS( 25),     DYS( 25),     ZLS( 25),     DC1S( 25),
     2     DC2S( 25),   PRF( 25),     PRAE( 25),    QM( 25),      WM( 25),
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3     PRAG(25),    ELEMN(25),
4     IOPOP( 25),  IPINL( 25), IPINR( 25), NC51( 25),  INLOP( 25),
5     NAL( 25),    NSXL( 25),  NSYL( 25),  NSZL( 25),  NAR( 25),
6     NSXR( 25),   NSYR( 25),  NSZR( 25),  NCDS( 25),  IAXOPS( 25)
 COMMON /BALA02/  JST(25),NJSS(25),HLJ(25),HRJ(25),VLJ(25),VUJ(25),
2     THKJ(25),GJ(25),SJC(25)
 COMMON /BLOCK4/  FORM(50,6),SMC(50,21),IST(50),  LT(50),
2     JT1(50),    JT2(50),       NITM(50),  IMM(50),   IMC(50)
 COMMON /BLOCK7/  F( 22),        AE( 22),    SX( 22),    SY( 22),
2     SZ( 22),    QX( 22),       QY( 22),    QZ( 22),    DX( 22),
3     DY( 22),    DZ( 22),       ERX( 22),   ERY( 22),   ERZ( 22),
4     SQX( 22),   SQY( 22),      SQZ( 22),   U1( 22),    V1( 22),
5     W1( 22),    U2( 22),       V2( 22),    W2( 22),    DS(3,3, 22),
6     BM1S( 22),  BM2S( 22),     TTS( 22),   AG( 22)
 COMMON /BLOC1/  ZMASS(25),FTMJXX(25),FTMJYY(25),FTMJZZ(25),
2     FTMJVV(25),TTMJ(25),NFTXX(25),NFTYY(25),NFTZZ(25),NFTVV(25)
 COMMON /BLOC16/  ERXXMJ(5,25),ERYYMJ(5,25),ERZZMJ(5,25),
2     DXXMJ(5,25),DYYMJ(5,25),DZZMJ(5,25),KOMJ(5,25),KOJ(25)
 COMMON /BALA16/  ERVVMJ(5,25),DVVMJ(5,25)
 COMMON /BLOC21/  ACCJT(100),VELJT(100),ZMASSR(100),DACCJT(100),
2     DVELJT(100),FACCJT(100),FDAMJT(100),CDAMP(100),DISJT(80,71)
 COMMON /BLOC22/  FJXT(25),FJYT(25),FJZT(25),FJVT(25),
2     DFJXT(25),DFJYT(25),DFJZT(25),DFJVT(25)
 COMMON /BLOC23/  DPFS(4,25)
 COMMON/BLOC24/   AN1(40),AN2(11),NPROB(2)
 COMMON /BLK1/   TOL,     ELEMNI,NJST,  KEEP3C,NCD3C,
2          KEEP2, KEEP3A,KEEP3B,KEEP4A,KEEP4B,KEEP4C,KEEP5A,
3          KEEP5B,KEEP5C,KEEP5D,KEEP6, KEEP7, NCD2,  NCD3A,
4          NCD3B, NCD4A, NCD4B, NCD4C, NCD5A, NCD5B, NCD5C,
5          NCD5D, NCD6,  NCD7,  IP8,   IP9,   IP10,  ITYPE,
6          IABAN, IFCRM, NM,    NJT,   NST,   NLT,   M,
7          MP1,   MP2,   ISTT,  LTT,   ITYPEL,IDJ,   NSTL
 COMMON /BLK3/ MNJT,MNST,MNLT,MNM,MNC5,MNC6,MDJT,MNJS,MNE,MNCS,
2     MNPCS,MNSS,MNQWM,MNJST,MNJSS
 COMMON /BLK5/ NFSUB,NITF,N1,N2
 COMMON /BLK7/ INLOPT,IFAE,KOFFJ,KOFFQW,KOFFSE
 COMMON / RI / NL, ML, J1
 COMMON/ITC/  ERR1,ERR2,ER1,ER2,DTI,CM,NTI,MM(20),MJ(20),MNITF,
2             MNITE,NSMJ,NSMM
 COMMON /WARN/ NJNC,NMNC
 COMMON /NIT/ A2ROB
 COMMON /SKT2/      WRX(25,10),  WRY(25,10),  WRZ(25,10),
2   . WRV(25,10),  WRXP(25,10), WRYP(25,10), WRTX(25,10),
3     WRTY(25,10), WRTZ(25,10), WRTV(25,10), WRTXP(25,10),
4     WRTYP(25,10)
 COMMON /SKT3/ NCOUNT, NITERF
 COMMON /SKT5/          WRXM (21,10),  WRYM (21,10),  WRZM (21,10),
2                       WRTXM(21,10),  WRTYM(21,10),  WRTZM(21,10)

 COMMON /SKT6/          NITERM(50), INDEX
 COMMON /SKT11/         MSSINL,        MSSIM1
 COMMON /SKT13/         EPR1S(21,10,3),EPRT1S(21,10,3),
2                       EPR2S(21,10,3),EPRT2S(21,10,3)
 COMMON /SKT14 / IRV(21,2,10),                 FOMOLD(50,6),
2                IRVRSE,        ITAPE,         N3
 COMMON /SKT15/  JJ
 COMMON /SKT17/  N4
 COMMON /SKT18/ NCHECK
 COMMON /SKT19/ JCRGON(25,6), JCUREV(25,6)
 COMMON /SKT20/ MCRGON(21,3), MCUREV(21,3)
 COMMON /SKT21/ NTR, NTRA
 COMMON /SKT22/ TIME, JT, IRDYN, IRSTEP(71)
 COMMON /SKT26/ LTYPEL
 COMMON /SKT27/ IREAD, IWRITE
 COMMON /SKT28/ FORCEL(20,71),STRANL(20,71),BMOMNL(20,71),
2     CURVAL(20,71),FORCER(20,71),STRANR(20,71),BMOMNR(20,71),
3     CURVAR(20,71),FRMAXF(20,71),FRMAXD(20,71),FRMMOM(20,71),
4     FRMROT(20,71),FRMSHF(20,71),FRMLTD(20,71),TOAXF(20,71),
5     TOAXD(20,71), TOMOM(20,71), TOROT(20,71), TOSHF(20,71),
6     TOLTD(20,71)
 COMMON /SKT30/ MSTIF(25), MLOAD(25), MODEL(25)
 COMMON /SKT32/ EPBF1 (21,10,3), EPBFT1(21,10,3), SLBF1 (21,10,3),
2               SLBFT1(21,10,3), EPBF2 (21,10,3), EPBFT2(21,10,3),
3               SLBF2 (21,10,3), SLBFT2(21,10,3),
4               EPSMAX(21,2,10), EPSMIN(21,2,10), EPSPRE(21,2,10),
5               YGROW (21,2,10), YTGROW(21,2,10)
 COMMON /SKT34/ ERXXDN(25), ERYYDN(25), ERZZDN(25), ERVVDN(25)
 COMMON /SKT35/ TMESTP
 COMMON /GT/ MJO
 CCMMON /CHA13/ GAMRS(25,3),GAMRTS(25,3)
 COMMON /CHA19/ JRV(25),JRGICN(25)
 COMMON /CHA28/ SHFORL(20,71),GAMMAL(20,71),SHFORR(20,71),
2     GAMMAR(20,71),SHMJT(20,71)
 COMMON /CHAN2/ SHMC(25)
 DATA PRINT /4HRINT/,PRNTNO /4HPRNO/, SAVE /4HSAVE/
 DATA MEMBER /4HMBER/
 DATA ANOW/4HANOW/,ANEW/4HANEW/
 DATA SHEAR /5HSHEAR/
11 FORMAT  (  5H1    ,80X , 10HI-----TRIM  )
12 FCRMAT ( 20A4 )
16 FORMAT  (///,   17H      PROB (CONTD),/,5X,A4,A1,10X,A5,7A8,A4,///)
18 FORMAT (///,4X, 30HRESULTS AT END OF TIME STEP = ,I5, 8H   AND   ,
2                    8H TIME = ,F10.5,///)
20 FORMAT(41HDYNAMIC SCLUTION FAILED TC CONVERGE AFTER,
2         10H ITERATION,I3)
40 FCRMAT (//,25X,10HTIME STEP ,I3,5X,7HTIME = ,F10.4,//)
41 FORMAT (1H1)
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   50 FORMAT (    51H     SOLUTION ABANDONED IN SEARCH OF AN INDEPENDENT
     2 ,          10H PROBLEM  ,////,
     3            49H     THE FOLLOWING CARDS WERE DISCARDED IN SEARCH,
     4            //)
   90 FORMAT (////  )
   92 FORMAT (///,39H DYNAMIC SOLUTION FAILED AT TIME STEP =,I5,
     2          14H     AND TIME =,F10.5,///)
   94 FORMAT (///,48H DYNAMIC SOLUTION FAILED WHILE TRYING TO PROCEED,
     2       21H TO NEXT TIME STEP = ,I5,14H     AND TIME =,F10.5,///)
   96 FORMAT (////,42H AVAILABLE RESULTS OF THE LAST STORED GOOD,
     2          45H SOLUTION,NOT NECESSARILY LAST GOOD SOLUTION,,//,
     3          18H ARE PRINTED BELOW,///)
   98 FORMAT ( // )
   99 FORMAT (//, 11(1PE11.3),/, 10(1PE11.3),/, 6(1PE11.3) )
  100 FORMAT ( 4(1PE14.4) )
  110 FORMAT (      31H JOINT DISPLACEMENTS AT TIME = ,F10.4,//)
  120 FORMAT (      31H JOINT VELOCITIES    AT TIME = ,F10.4,//)
  130 FORMAT (      31H JOINT ACCLERATIONS  AT TIME = ,F10.4,//)
  154 FORMAT (//,48H          * INDICATES JOINT SUPPORT OFF Q-W CURVE AT,
     2          20H END OF THIS PROBLEM)
  155 FORMAT (///30H          ***** FRAME ITERATION NO ,I5,6H *****,//,
     2      5X,     43H MEMB MEMB             MEMBER DISPLACEMENTS      ,
     3     11X,     25H MEMBER EQULIBRIUM ERRORS,/,
     4      5X,     46H  NO  ITER        AXIAL  LATERAL  ROTATIONAL     ,
     5      3X,     32H AXIAL      LATERAL    ROTATIONAL)
  192 FORMAT (     50H **ATTEMPTED DIVISION BY ZERO IN JOINT SOLUTION **)
  195 FORMAT (//,96X,  34H-----REVERSAL HAS BEEN SENSED----- )
  200 FORMAT (1H1,20(/),40H  THIS IS AUTO TIME STEP REDUCT. PROBLEM
     2       , 10(/) )
  205 FORMAT (1H1,/,1X,14HMEMBER NUMBER ,I3,2X,19HMEMBER RESPONSES IN ,
     2 56H THE DIRECTION OF ORIGINAL GEOMETRY - RECORDED HYSTERSIS,//)
  206 FORMAT (1X,16HMEMBER NUMBER = ,I3,26H--MEMBER RESPONSE AT THE ,
     2          10HLEFT END--)
  207 FORMAT (1X,16HMEMBER NUMBER = ,I3,26H--MEMBER RESPONSE AT THE ,
     2          11HRIGHT END--)
  210 FORMAT (20X,25H---- AT THE LEFT  END ---,/)
  211 FORMAT (20X,25H---- AT THE RIGHT END ---,/)
  212 FORMAT (1X, 4HTIME,/,37H STEP     TIME      AX.FORCE   AX.DISPL ,
     2          43H   MOMENT      ROTATION    SH.FORCE  LAT.DISPL,/)
  220 FORMAT (1H1,/,1X,14HMEMBER NUMBER ,I3,2X,19HSECTION RESPONSE IN,
     2 56H THE DIRECTION OF DEFORMED GEOMETRY - RECORDED HYSTERSIS,//)
  221 FORMAT (16HMEMBER NUMBER = ,I3,25H-RESPONSE OF THE SECTION ,
     2        27HCLOSEST TO THE -FROM- JOINT)
  222 FORMAT (16HMEMBER NUMBER = ,I3,25H-RESPONSE OF THE SECTION ,
     2        27HCLOSEST TO THE  -TO-  JOINT)
  230 FORMAT (1X, 4HTIME,/,37H STEP     TIME      AX.FORCE    AX.STRAIN,
     2          22H   MOMENT      CURVATURE,/)
  234 FORMAT (5X,44HTABLE 8 - JOINT DISPLACEMENTS. REACTIONS AND.
     2 29H SHEAR PANEL INTERNAL MOMENTS,///,
     3 57H  JNT      DISP(X)            DISP(Y)            ROT(Z)          RO,
     4 50HT(V)       REACT(X)     REACT(Y)     REACT(Z)     REACT(V),
     5 24H     SHR.MOM(Z)  SHR.MOM(V),//)
  235 FORMAT  ( 1X,     I4,  4(1PE15.7),  6(1PE11.3) )
  236 FORMAT (1X,1H*,I3,4(1PE15.7),6(1PE11.3))
  237 FORMAT (65X,4(11H ----------),//,60X,5HTOTAL,4(1PE11.3),
     2        //, 65X,4(11H ----------))
  238 FORMAT (5X,34HTABLE 10 - JOINT EQULIBRIUM ERRORS,///,
     2 4X,5HJOINT,3X,6HERR(X),9X,6HERR(Y),10X,6HERR(Z),9X,6HERR(V),/,
     3 12X,5HFORCE,10X,5HFORCE,11X,6HMOMENT,9X,6HMOMENT,//)
  250 FORMAT (//,51H ** PRINT OPTION IS LIMITED TO # OF MEMBERS * # OF ,
     2          16H TIME STEPS = 30,//)
  251 FORMAT (20X,47H---------- SECTION CLOSEST TO THE  -FROM-  JOINT,/)
  252 FORMAT (20X,47H---------- SECTION CLOSEST TO THE   -TO-   JOINT,/)
  253 FORMAT (1X, 4HTIME,/,37H STEP     TIME      AX.FORCE    AX.STRAIN,
     2          44H   MOMENT      CURVATURE  SH.FORCE    SH.STRAIN,/)
  254 FORMAT (1X,I3,7(1PE11.3))
  255 FORMAT (2I3,F6.3,6(1PE10.3))
  256 FORMAT (1X,15HJOINT NUMBER = ,I3,29H--RECORDED DISPLACEMENTS AND ,
     2          17HSHEAR MOMENT(Z)--)
  257 FORMAT (2I3,F6.3,5(1PE12.5))
  260 FORMAT (      15H CHECK THE DATA)
  777 FORMAT (      48H       ***  SOLUTION DID NOT CLOSE - STUDY MONITOR,
     2          10H DATA *** )
            NTEMP = NTI * NM
        IF ( APROB .NE. PRINT ) GO TO 400
        IF ( NTEMP .LE. 30 )    GO TO 400
            PRINT = PRNTNO
      PRINT 250
400     CONTINUE
            TEMP = NTI
            TOTTME = TEMP * DTI
            NTR = 0
            NJTT = 3*NJT
        DO 410 I = 1,NJT
        IF (JST(I) .EQ. 0) GO TO 410
            NJTT = NJTT + 1
410     CONTINUE
            J = 0
        DO 500 I = 1,NJT
        IF(ZMASS(I) .GE. 0.0) GO TO 420
            J = J + 1
            ZMASSR(J) = -ZMASS(I)
            J = J + 1
            ZMASSR(J) = 0.0
        GO TO 430
420         J = J + 1
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                 ZMASSR(J) = ZMASS(I)
                 J = J + 1
 430             ZMASSR(J) = ZMASS(I)
                 J = J + 1
                 ZMASSR(J) = 0.0
         IF(JST(I) .EQ. 0) GO TO 500
                 J = J + 1
                 ZMASSR(J) = 0.0
 500     CONTINUE
         DO 550 I = 1,NJTT
                 CDAMP(I)=CM*ZMASSR(I)
         IF (DABS(ZMASSR(I)) .GE. 1.0E+15) CDAMP(I)=0.0
 550     CONTINUE
         IF (ITYPE .EQ. 4 )GC TO 900
         DO 600 I = 1,NJTT
                 VELJT(I) = 0.0
 600 CONTINUE
                 TIME = 0.0
 900     CONTINUE
                 DSS1 = 4.0/DTI
                 DSS2 = DSS1/DTI
COMMENT - IF THIS IS A CONTINUATICN OF TYPE# 9 PROBLEM, THEN VALUES
COMMENT - MUST BE READ FRCM UNIT 'IREAD'
          IF ( ITYPEL .EQ. 9 ) GO TO 940
COMMENT - IF THIS IS A NCRMAL CONTINUATION OF TYPE 1 OR TYPE 2 PROBLEM
COMMENT - THEN UNIT 'IREAD' IS NOT READ
          IF ( ITYPEL .LE. 2 ) GO TO 1000
COMMENT - IF THIS IS A NORMAL CONTINUATION OF TYPE 3 OR TYPE 4 PROBLEM
COMMENT - THEN UNIT 'IREAD' IS NOT READ
          IF ( NTR .EQ. 0 ) GO TO 1000
 940      CONTINUE
      REWIND 13
      READ (13) IREAD
          IF ( IREAD .EQ. 11 ) IWRITE = 12
          IF ( IREAD .EQ. 12 ) IWRITE = 11
COMMENT - READ OFF UNIT 'IREAD'
      REWIND IREAD
      READ ( IREAD ) ( DXX(I), DYY(I), DZZ(I), DVV(I), I=1,NJT )
      READ (IREAD) ((GAMRS(I,J),GAMRTS(I,J),J=1,3),I=1,NJT)
COMMENT - INITIALISE REVERSAL INDICATORS FOR JOINT SHEAR STRESS-STRAIN
COMMENT - CURVES.
          DO 941 I = 1,NJT
                 JRV(I) = 0
 941      CONTINUE
          DO 942 I = 1,NJT
                 NTEMP = NSXX(I)+NSYY(I)+NSZZ(I)+NSVV(I)+NSXP(I)+NSYP(I)
          IF ( NTEMP .EQ. 0 ) GO TO 942
      READ (IREAD )   (WRX(I,J),WRTX(I,J),WRY(I,J),WRTY(I,J),WRZ(I,J),
     2                 WRTZ(I,J),WRV(I,J),WRTV(I,J),WRXP(I,J),WRTXP(I,J),
     3                 WRYP(I,J),WRTYP(I,J), J = 1,10 )
 942      CONTINUE
COMMENT - INITIALISE REVERSAL INDICATCRS FOR JOINT CURVES
          DO 945  I = 1,MNJT
          DO 945  N = 1,6
                 JCUREV(I,N) = 0
 945      CONTINUE
COMMENT - IF THE LAST GOOD SOLUTICN STCRED ON UNIT 'IREAD' WAS ENDING IN
COMMENT - STATIC ANALYSIS THEN, VELOCITIES ETC, ARE NOT APPLICABLE
          IF ( ITYPEL .EQ. 9 .AND. ITYPE .EQ. 3 ) GO TO 950
      READ  ( IREAD  ) JT, TIME, ( VELJT(I), I=1,NJTT )
      READ  ( IREAD ) ( ACCJT(I), I=1,NJTT )
 950      CONTINUE
      REWIND N2
      REWIND N4
          DO 980 JJ = 1,NM
                 ISTT = IST(JJ)
          IF ( ISTT .EQ. 0 ) GO TO 980
                 MODELT = MODEL(ISTT)
                 ELEMNT = ELEMN(ISTT)
                 NHINGE = 2
                 M = MSTIF (ISTT)
                MP1= M+1
                MP2= M+2
      READ ( IREAD ) ( DX(I), DY(I), DZ(I), I=1,MP2 )
      WRITE(N2) ( DX(I), DY(I), DZ(I), I=1,MP2 )
          IF ( INLOP(ISTT) .EQ. 0 ) GO TO 980
                 NREAD = NSXL(ISTT)+NSYL(ISTT)+NSZL(ISTT)
          IF ( NREAD .EQ. 0 ) GO TO 952
      READ (IREAD )  ((WRXM(I,J),WRTXM(I,J),WRYM(I,J),WRTYM(I,J),
     2                WRZM(I,J), WRTZM(I,J), J=1,10), I=2,MP1 )
      WRITE (N2)  (( WRXM(I,J), WRTXM(I,J), WRYM(I,J), WRTYM(I,J),
     2                WRZM(I,J), WRTZM(I,J), J=1,10), I=2,MP1 )
 952      CONTINUE
          IF ( MODELT .LE. -1 ) GO TO 954
          IF (ELEMNT .EQ. SHEAR) GO TO 953
      READ (IREAD )  (((EPR1S(I,J,K),EPRT1S(I,J,K),EPR2S(I,J,K),
     2                 EPRT2S(I,J,K),K=1,MSSIM1), J=1,MNPCS), I=2,MP1 )
      WRITE (N2)  ((( EPR1S(I,J,K), EPRT1S(I,J,K), EPR2S(I,J,K),
     2                 EPRT2S (I,J,K),K=1,MSSIM1), J=1,MNPCS), I=2,MP1 )
          IF ( MODELT .EQ.  0 ) GC TO 954
      READ  (IREAD )  (((EPBF1  (I,J,K), EPBFT1(I,J,K), SLBF1  (I,J,K),
     2                   SLBFT1(I,J,K), EPBF2  (I,J,K), EPBFT2(I,J,K),
     3                   SLBF2  (I,J,K), SLBFT2(I,J,K), K=1,MSSIM1 ),
     4                   J = 1,MNPCS ), I = 2,MP1 )
      WRITE (N2    )  (((EPBF1  (I,J,K), EPBFT1(I,J,K), SLBF1  (I,J,K),
     2                   SLBFT1(I,J,K), EPBF2  (I,J,K), EPBFT2(I,J,K),
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     3               SLBF2 (I,J,K), SLBFT2(I,J,K), K=1,MSSIM1 ),
     4               J = 1,MNPCS ), I = 2,MP1 )
        GO TO 95301
  953   CONTINUE
              NHINGE = 1
        READ (IREAD ) (((EPR1S(I,J,K),EPRT1S(I,J,K),
     2               K = 1,MSSIM1), J=1,MNPCS), I=2,MP1 )
        WRITE (N2) ((( EPR1S(I,J,K), EPRT1S(I,J,K),
     2               K = 1,MSSIM1), J=1,MNPCS), I=2,MP1 )
        IF ( MODELT .EQ.  0 ) GO TO 954
        READ  (IREAD ) (((EPBF1 (I,J,K), EPBFT1(I,J,K), SLBF1 (I,J,K),
     2               SLBFT1(I,J,K), K=1,MSSIM1 ),J=1,MNPCS),I=2,MP1)
        WRITE (N2    ) (((EPBF1 (I,J,K), EPBFT1(I,J,K), SLBF1 (I,J,K),
     2               SLBFT1(I,J,K), K=1,MSSIM1 ),J=1,MNPCS),I=2,MP1)
95301   CONTINUE
        READ  (IREAD ) (((EPSMAX(I,L,J), EPSMIN(I,L,J), EPSPRE(I,L,J),
     2               J = 1,MNPCS ), L = 1,NHINGE ), I = 2,MP1 )
        WRITE (N2    ) (((EPSMAX(I,L,J), EPSMIN(I,L,J), EPSPRE(I,L,J),
     2               J = 1,MNPCS ), L = 1,NHINGE ), I = 2,MP1 )
        IF ( MODELT .NE.  2 ) GC TO 954
        READ  (IREAD ) (((YGROW (I,L,J), YTGROW(I,L,J), J = 1,MNPCS ),
     2               L = 1,NHINGE ), I = 2,MP1 )
        WRITE (N2    ) (((YGROW (I,L,J), YTGROW(I,L,J), J = 1,MNPCS ),
     2               L = 1,NHINGE ), I = 2,MP1 )
  954   CONTINUE
        IF ( NREAD .EQ. 0 ) GO TO 958
        DO 955 I = 2,MP1
        DO 955 N = 1,3
              MCUREV(I,N) = 0
  955   CONTINUE
      WRITE (N4) ((MCUREV(I,N), N=1,3), I=2,MP1 )
  958   CONTINUE
        IF ( MODELT .LE. -1 ) GC TO 980
        DO 960 I = 2,MP1
        DO 960 L = 1,NHINGE
        DO 960 J = 1,MNPCS
              IRV(I,L,J) = 0
  960   CONTINUE
      WRITE (N4) ((( IRV(I,L,J), J=1,MNPCS), L=1,NHINGE), I=2,MP1 )
  980   CONTINUE
 1000   CONTINUE
        IF ( NTR .NE. 0 ) GO TO 1020
              TOTTME = TOTTME + TIME
 1020   CONTINUE
              LTYPEL = ITYPEL
              ITYPEL = ITYPE
              TIME = TIME - DTI
              IABAN = 0
              NJNC = 0
              NTI1 = NTI + 1
        DO 1030 I = 1,NTI1
 1030         IRSTEP(I) = 0
              JT = 0
 1040         JT = JT + 1
              TIME = TIME+DTI
        IF ( APROB .EQ. PRINT .OR. APROB .EQ. MEMBER ) GO TO 1044
        GO TO 1046
 1044   CONTINUE
        IF (JT .EQ. 1) PRINT 41
      PRINT 40,JT,TIME
 1046   CONTINUE
              NITF = 0
              NITERF = 1
              IRDYN = 0
              IRVRSE= 0
 1050   CONTINUE
        IF ( IRVRSE .EQ. 0 ) GO TO 1060
        IF ( APROB .EQ. PRINT .OR. APROB .EQ. MEMBER ) GO TO 1055
        GO TO 1060
 1055   CONTINUE
      PRINT 195
 1060   CONTINUE
              ITAPE = 1
        IF ( IRVRSE .NE. 0 ) ITAPE = 0
        IF ( ITAPE .EQ. 0 ) GO TO 1070
 1065   CONTINUE
              NT = N2
              N2 = N1
              N1 = NT
 1070   CONTINUE
              NT = N4
              N4 = N3
              N3 = NT
              NITF = NITF + 1
              NMJ = 0
              KOFFJ = 0
              NCHECK = 0
              INDEX = 0
        IF ( ( IRSTEP(JT)+IRDYN ) .NE. 0 ) GO TO 1100
        IF (NITERF .NE. 1) GO TC 1100
        IF (JT .EQ. 1) GO TC 1100
              NCHECK = 1
              INDEX = 1
 1100   CONTINUE
              IRVRSE = 0
COMMENT - SOLVE FOR JOINT REACTIONS
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              DO 1250 I = 1,NJT
COMMENT  -    SUBROUTINE INELST CALCULATES THE RESISTIVE SPRING FORCE AND
COMMENT  -    THE SPRING STIFFNESS FOR THE JOINT SPRINGS FOLLOWING
COMMENT  -    NONLINEAR LOADING , INELASTIC UNLOADING PATH
      CALL          INELST (I,SJX,SJY,SJZ,SJV,SJXY,QJX,QJY,QJZ,QJV)
              IF ( IRVRSE .NE. 0 ) GO TO 1250
                    RXX(I) = - SXX(I)*DXX(I) + QJX
                    RYY(I) = - SYY(I)*DYY(I) + QJY
                    RZZ(I) = - SZZ(I)*DZZ(I) + QJZ
                    RVV(I) = - SVV(I)*DVV(I) + QJV
                    KOJ(I) = KOFFJ
              IF (IMJ(I) .EQ. 0) GO TO 1250
                    NMJ = NMJ+1
                    KOMJ(NMJ,NITF) = KOFFJ
 1250         CONTINUE
COMMENT  -    CALL SUBROUTINE DJSTSM TO OBTAIN THE SHEAR MOMENT AT EACH
COMMENT  -    JOINT.
              DO 1300 I = 1,NJT
                    SHMO(I) = 0.0
              IF (JST(I) .EQ. 0) GO TO 1300
      CALL          DJSTSM(I,STFJ,SHMOJ)
              IF (IRVRSE .NE. 0) GO TO 1300
                    SHMO(I) = SHMOJ
 1300         CONTINUE
                    NITERF = NITERF + 1
              IF (IRVRSE .NE. 0 ) GO TO 1600
COMMENT  -    COMPUTE FOR EACH JOINT - THE SUM OF APPLIED JOINT LOAD
COMMENT  -    AND THE REACTION - WHEN THE APPROPRIATE MEMBER END FORCES
COMMENT  -    ARE SUBTRACTED FROM THIS SUM THE RESULT IS THE JOINT
COMMENT  -    EQUILIBRIUM ERRORS.FOR JOINT SHEAR OPTION SUBTRACT ALSO THE
COMMENT  -    FORCES THAT ARE CARRIED BY THE JOINT SHEAR DEFORMATION.
              DO 1500 I = 1,NJT
                    ERXX(I) = QXX(I) + RXX(I)
              IF (DABS(QXX(I)) .GE. 1.0E+15) ERXX(I) = 0.0
                    ERYY(I) = QYY(I) + RYY(I)
              IF (DABS(QYY(I)) .GE. 1.0E+15) ERYY(I) = 0.0
                    ERZZ(I) = QZZ(I) + RZZ(I) - SHMO(I)
              IF(DABS(QZZ(I)) .GE. 1.0E+15) ERZZ(I) = 0.0
              IF (JST(I) .NE. 0) GO TO 1400
                    ERVV(I) = 0.0
              GO TO 1500
 1400         CONTINUE
                    ERVV(I) = QVV(I) + RVV(I) + SHMO(I)
              IF (DABS(QVV(I)) .GE. 1.0E+15) ERVV(I) = 0.0
 1500         CONTINUE
 1600         CONTINUE
COMMENT  -    INITIALISE THE FOLLOWING VECTORS USED IN SUBROUTINE  ADJTER
              DO 1650 I = 1,NJT

                    ERXXDN(I) = 0.0
                    ERYYDN(I) = 0.0
                    ERZZDN(I) = 0.0
                    ERVVDN(I) = 0.0
 1650         CONTINUE
          REWIND N1
          REWIND N2
          REWIND N3
          REWIND N4
              IF ( APROB .EQ. PRINT .OR. APROB .EQ. MEMBER ) GO TO 1700
              GO TO 1710
 1700         CONTINUE
          PRINT 155, NITF
 1710         CONTINUE
                    TMESTP = ANOW
                    IFAE = 0
                    NMNC = 0
              DO 2000 JJ = 1,NM
                    ISTT = IST(JJ)
                    LTT = LT(JJ)
                    IMC(JJ)=0
                    NITM(JJ)=0
CCOMMENT  -   SKIP FOR NULL MEMBER
              IF (ISTT.EQ.0)GO TO 1850
      CALL MEMSOL ( RM, RO, W, SL, L1, L3, L4, L6 )
              IF (IMC(JJ) .EQ. 1)  NMNC = NMNC + 1
              GO TO 1950
COMMENT  -    SET MEMBER END FORCE-MATRIX TO NULL MATRIX FOR NULL MEMBER
 1850         DO 1900 I = 1,6
 1900               FOMM(JJ,I) = 0.0
 1950         CONTINUE
COMMENT  -    IF REVERSAL HAS BEEN SENSED AT THE BEGINNING OF
COMMENT  -    A NEW TIME STEP , THEN SKIP STIFFNESS FORMATION CALCULATIONS
COMMENT  -    AT THIS TIME STEP SINCE WRONG INCREMENTS HAVE ALREDY BEEN
COMMENT  -    ADDED TO THE JOINT DISPLACEMENTS AT THE END OF LAST TIME STEP.
COMMENT  -    SO EVERYTHING MUST BE BACKED UP TO THE LAST TIME STEP, CORRECT
COMMENT  -    STIFFNESS MUST BE FORMED AT ITS END, REVISED INCREMENTS MUST
COMMENT  -    BE ADDED TO JOINT DISPLACEMENTS, AND AGAIN THE NEXT TIME STEP
COMMENT  -    MUST BE BEGUN.
              IF ( IRVRSE .NE. 0 ) GO TO 2000
              IF (NMNC .GT. 0 ) PRINT 777
COMMENT  -    IF SOLUTION FAILS FOR ANY REASON, THEN THE LAST GOOD STORED
COMMENT  -    SOLUTION ( NOT NECESSARILY THE LAST GOOD SOLUTION SOLVED FOR )
COMMENT  -    IS READ AND RESULTS OUTPUT BEFORE PROCEEDING FURTHER
COMMENT  -    SIMILAR THINGS ARE DONE IN CASE OF FAILURE IN JOINT SOLUTION
COMMENT  -    EITHER WITHIN THE TIME STEP OR AT A NEW TIME STEP
              IF ( NMNC .EQ. 0 ) GO TO 1955
                    IABAN = 1
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      PRINT 92, JT, TIME
           IF ( JT .EQ. 1 ) GO TO 11100
      GO TO 3870
 1955      CONTINUE
                INDEX = 0
                NCHECK = 0
           IF ( ISTT .EQ. 0 ) GO TO 2000
COMMENT - SUBROUTINE FORMST CALCULATES MEMBER (6 X 6) STISFNESS MATRIX
COMMENT - AND TAKING ADVANTAGE OF SYMMETRY STORES IN COMPACT VECTOR
COMMENT - SMMT(I = 1,2)
      CALL      FORMST ( RM, RC, W, SL, SMMT, L1, L3, L4, L6, JJ )
           DO 1960 I = 1,21
 1960           SMC( JJ ,I) = SMMT(I)
 2000      CONTINUE
           IF ( IRVRSE .EQ. 0 ) GO TO 2015
COMMENT - DECREMENT TIME STEP PARAMETERS & JOINT DISPLACEMENTS,
COMMENT - VELOCITIES,AND ACCELERATIONS
                NITF        = NITF - 1
                NITERF      = NITERF - 1
                IRDYN       = 1
                IRSTEP(JT)  = 1
                JT          = JT - 1
                TIME        = TIME - DTI
           DO 2005 I = 1,NJTT
                VELJT(I) = VELJT(I) - DVELJT(I)
                ACCJT(I) = ACCJT(I) - DACCJT(I)
 2005      CONTINUE
                J = 0
           DO 2010 I = 1,NJT
                J = J + 1
                DXX(I) = DXX(I) - DELWJT(J)
                J = J + 1
                DYY(I) = DYY(I) - DELWJT(J)
                J = J + 1
                DZZ(I) = DZZ(I) - DELWJT(J)
           IF (JST(I) .NE. 0) GO TO 2008
                DVV(I) = 0.0
           GO TO 2010
 2008           J = J + 1
                DVV(I) = DVV(I) - DELWJT(J)
 2010      CONTINUE
      GO TO 1050
 2015      CONTINUE
COMMENT - DUMP OF STIFFNESS MATRIX AND LOAD VECTOR,TO ACTIVATE,SET LAST
COMMENT - FIVE COLUMNS IN PROBLEM NUMBER CARD EQUAL TO PRINT
           IF ( APROB .NE. PRINT ) GO TO 2060
           DO 2050 JJ = 1,NM
           DO 2040  I = 1,6
                FOMTEM(JJ,I) = 0.0
 2040      CONTINUE
                ISTT = IST(JJ)
           IF (ISTT.EQ.0)GO TO 2050
      PRINT 99, ( SMC(JJ,I), I=1,21), ( FOMTEM(JJ,I), I=1,6 )
 2050      CONTINUE
 2060      CONTINUE
           DO 3000 I = 1,NJT
           IF (NITF .GT. 1) GO TO 2900
      CALL DYSTLD ( FJX,FJY,FJZ,FJV,TIME,I)
                FJXT(I) = FJX
                FJYT(I) = FJY
                FJZT(I) = FJZ
                FJVT(I) = FJV
 2900      CONTINUE
                ERXX(I) = FJXT(I) + ERXX(I)
                ERYY(I) = FJYT(I) + ERYY(I)
                ERZZ(I) = FJZT(I) + ERZZ(I)
                ERVV(I) = FJVT(I) + ERVV(I)
 3000      CONTINUE
                NCHECK = 0
                INDEX = 0
           IF ( JT .GT. 1) GO TO 3200
           IF ( ITYPE .EQ. 4 ) GO TO 3200
                J = 0
           DO 3100 I = 1,NJT
                J = J + 1
           IF (ZMASSR(J) .GT. 1.0D-10) GO TO 3010
                ACCJT(J) = 0.0
           GO TO 3020
 3010           ACCJT(J) = ERXX(I)/ZMASSR(J)
 3020           J = J + 1
           IF (ZMASSR(J) .GT. 1.0D-10) GO TO 3030
                ACCJT(J) = 0.0
           GO TO 3040
 3030           ACCJT(J) = ERYY(I)/ZMASSR(J)
 3040           J = J + 1
                ACCJT(J) = 0.0
           IF (JST(I) .EQ. 0) GO TO 3100
                J = J + 1
                ACCJT(J) = 0.0
 3100      CONTINUE
 3200      DO 3250 I=1,NJTT
                FACCJT(I)=ZMASSR(I)*ACCJT(I)
                FDAMJT(I )=CDAMP(I)*VELJT(I)
 3250      CONTINUE
                J = 0
           DO 3300 I=1,NJT
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            J = J + 1
            ERXX(I) = ERXX(I) - FACCJT(J) - FDAMJT(J)
      IF(DABS(FJXT(I)) .GT. 1.00E+10) ERXX(I) = 0.0
            J = J + 1
            ERYY(I) = ERYY(I) - FACCJT(J) - FDAMJT(J)
      IF(DABS(FJYT(I)) .GT. 1.00E+10) ERYY(I) = 0.0
            J = J + 1
            ERZZ(I) = ERZZ(I) - FACCJT(J) - FDAMJT(J)
      IF(DABS(FJZT(I)) .GT. 1.00E+10) ERZZ(I) = 0.0
      IF (JST(I) .NE. 0) GO TC 3260
            ERVV(I) = 0.0
      GO TO 3300
 3260 CONTINUE
            J = J + 1
            ERVV(I) = ERVV(I) - FACCJT(J) - FDAMJT(J)
      IF (DABS(FJVT(I)) .GT. 1.00E+10) ERVV(I) = 0.0
 3300 CONTINUE
      DO 3400 I = 1,NJT
      IF (DABS(QXX(I)).LT.1.0E+15.AND.DABS(FJXT(I)).LT.1.0E+10)
     2 GO TO 3320
            ERXX(I) = ERXXDN(I)
 3320 CONTINUE
      IF (DABS(QYY(I)).LT.1.0E+15.AND.DABS(FJYT(I)).LT.1.0E+10)
     2 GO TO 3330
            ERYY(I) = ERYYDN(I)
 3330 CONTINUE
      IF (DABS(QZZ(I)).LT.1.0E+15.AND.DABS(FJZT(I)).LT.1.0E+10)
     2 GO TO 3340
            ERZZ(I) = ERZZDN(I)
 3340 CONTINUE
      IF (JST(I) .EQ. 0) GO TC 3400
      IF (DABS(QVV(I)).LT.1.0E+15.AND.DABS(FJVT(I)).LT.1.0E+10)
     2 GO TO 3400
            ERVV(I) = ERVVDN(I)
 3400 CONTINUE
COMMENT - IRDYN = 1      DENOTES THAT THE PARTICULAR TIME STEP BEING
C         EXECUTED NOW HAS ALREADY BEEN COMPLETLY SOLVED ONCE , BUT IS
C         ACCESSED  AGAIN THIS TIME ONLY FOR THE PURPOSE OF
C         (BACKED UP) STIFFNESS FORMATION
      IF ( IRDYN .EQ. 1 ) GC TO 3950
      DO 3700 I = 1,NJT
      IF (DABS(QXX(I)).LT.1.0E+15.AND.DABS(FJXT(I)).LT.1.0E+10)
     2 GO TO 3510
      GO TO 3515
 3510 CONTINUE
      IF (DABS(ERXX(I)) .GT. ERR1) GO TO 5100
 3515 CONTINUE
      IF (DABS(QYY(I)).LT.1.0E+15.AND.DABS(FJYT(I)).LT.1.0E+10)
     2 GO TO 3520
      GO TO 3525
 3520 CONTINUE
      IF (DABS(ERYY(I)) .GT. ERR1) GO TO 5100
 3525 CONTINUE
      IF (DABS(QZZ(I)).LT.1.0E+15.AND.DABS(FJZT(I)).LT.1.0E+10)
     2 GO TO 3530
      GO TO 3535
 3530 CONTINUE
      IF (DABS(ERZZ(I)) .GT. ERR2) GO TO 5100
 3535 CONTINUE
      IF (DABS(QVV(I)).LT.1.0E+15.AND.DABS(FJVT(I)).LT.1.0E+10)
     2 GO TO 3540
      GO TO 3700
 3540 CONTINUE
      IF (DABS(ERVV(I)) .GT. ERR2) GO TO 5100
 3700 CONTINUE
      IF (NSMJ .EQ. 0) GO TO 3702
      DO 3701 II = 1,NSMJ
            I = MJ(II)
      SHMJT(II,JT) = SHMO(I)
 3701 CONTINUE
 3702 CONTINUE
COMMENT - PRINT TABLE 8 IF REQUESTED
COMMENT - EVEN IF NOT REQUESTED, PRINT RESULTS FOR THE LAST TIME STEP
      IF ( JT .EQ. NTI1 ) GO TO 3710
      IF ( IP8 .EQ. 0 ) GO TO 3860
      IF ((JT-1)/IP8*IP8 .NE. JT-1) GO TO 3860
 3710 CONTINUE
      PRINT 11
      PRINT 16, NPRCB,(AN2(II),II=1,9)
      PRINT 18, JT,TIME
      PRINT 234
            KASTER = 0
            TEMPXX = 0.0
            TEMPYY = 0.0
            TEMPZZ = 0.0
            TEMPVV = 0.0
      DO 3850 I = 1,NJT
      SHMOJ = -SHMO(I)
      IF (KOJ(I) .EQ. 1) GO TC 3800
      PRINT 235, I, DXX(I), DYY(I), DZZ(I), DVV(I), RXX(I), RYY(I),
     2 RZZ(I), RVV(I), SHMO(I), SHMOJ
      GO TO 3840
 3800       KASTER = 1
      PRINT 236, I, DXX(I), DYY(I), DZZ(I), DVV(I), RXX(I), RYY(I),
     2 RZZ(I), RVV(I), SHMO(I), SHMOJ
 3840 CONTINUE
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      IF (DABS(QXX(I)).GE.1.0E+15. OR.DABS(FJXT(I)).GE.1.0E+10)
    2 GO TO 3842
            TEMPXX = TEMPXX + RXX(I)
 3842 CONTINUE
      IF (DABS(QYY(I)).GE.1.0E+15. OR.DABS(FJYT(I)).GE.1.0E+10)
    2 GO TO 3844
            TEMPYY = TEMPYY + RYY(I)
 3844 CONTINUE
      IF (DABS(QZZ(I)).GE.1.0E+15. OR.DABS(FJZT(I)).GE.1.0E+10)
    2 GO TO 3846
            TEMPZZ = TEMPZZ + RZZ(I)
 3846 CONTINUE
      IF (DABS(QVV(I)).GE.1.0E+15 .OR. DABS(FJVT(I)).GE.1.0E+10)
    2 GO TO 3850
            TEMPVV = TEMPVV + RVV(I)
 3850 CONTINUE
      PRINT 237, TEMPXX, TEMPYY, TEMPZZ, TEMPVV
         IF ( KASTER .EQ. 1) PRINT 154
 3860 CONTINUE
         IF ( JT .GT. 1 ) GO TO 3865
         IF ( LTYPEL .NE. 9 ) GO TO 3865
      PRINT 90
      PRINT 120, TIME
      PRINT 100, ( VELJT(I) , I = 1,NJTT )
      PRINT 90
      PRINT 130, TIME
      PRINT 100, ( ACCJT(I) , I = 1,NJTT )
 3865    CONTINUE
      REWIND N1
      REWIND N2
            NT = N1
            N1 = N2
            N2 = NT
 3870    CONTINUE
         IF ( IABAN .EQ. 0 ) GO TO 3890
      REWIND 13
      READ (13) IREAD
      REWIND IREAD
      READ (IREAD)  (DXX(I),DYY(I),DZZ(I),DVV(I),I=1,NJT)
      READ (IREAD)  ((GAMRS(I,J),GAMRTS(I,J),J=1,3),I=1,NJT)
         DO 3880 I = 1,NJT
            NTEMP = NSXX(I)+NSYY(I)+NSZZ(I)+NSVV(I)+NSXP(I)+NSYP(I)
         IF ( NTEMP .EQ. 0 ) GO TO 3880
      READ (IREAD )    (WRX(I,J),WRTX(I,J),WRY(I,J),WRTY(I,J),WRZ(I,J),
     2                 WRTZ(I,J),WRV(I,J),WRTV(I,J),WRXP(I,J),WRTXP(I,J),
     3                 WRYP(I,J),WRTYP(I,J), J = 1,10 )
 3880    CONTINUE
      READ  ( IREAD  ) JT, TIME, ( VELJT(I) , I=1,NJTT )
      READ  ( IREAD ) ( ACCJT(I), I=1,NJTT )
            NTI1 = JT
            NTI  = NTI1 - 1
      PRINT 96
      PRINT 18, JT, TIME
 3890    CONTINUE
COMMENT - SUBROUTINE PRINT 9 OUTPUTS MEMBER RESUTS
      CALL PRINT9(AN2,NPROB,RM,RO,W,SL,L1,L3,L4,L6)
 3900    CONTINUE
        IF ( IABAN .NE. 0 ) GO TO 3950
         IF ( JT .EQ. NTI1 ) GO TO 3910
         IF ( IP10 .EQ. 0 ) GO TO 3950
COMMENT - PRINT TABLE 10 IF REQUESTED
         IF ((JT-1)/IP10*IP10 .NE. JT-1) GO TO 3950
 3910    CONTINUE
      PRINT 11
      PRINT 16,NPROB,(AN2(II),II=1,9)
      PRINT 238
         DO 3940 I = 1,NJT
 3940 PRINT 235, I, ERXX(I), ERYY(I), ERZZ(I), ERVV(I)
      PRINT 90
 3950    CONTINUE
         IF ( JT .EQ. NTI1 ) GO TO 10000
COMMENT - NEW TIME STEP
            TIME2 = TIME + DTI
            TMESTP = ANEW
      REWIND N1
            NT = N3
            N3 = N4
            N4 = NT
      REWIND N3
            IFAE   = 1
            NCHECK = 0
            INDEX  = 0
        DO 4000 JJ = 1,NM
            ISTT   = IST (JJ)
            LTT    = LT (JJ)
        IF ( ISTT .EQ. 0 ) GO TO 4000
      CALL FORMST ( RM, RC, W, SL, SMMT, L1, L3, L4, L6, JJ )
      CALL FORMLD ( RM, RC, W, SL, FOMT, L1, L3, L4, L6, JJ )
        DO 3970 I = 1,6
            FOMM(JJ,I) = FOMT(I)
 3970   CONTINUE
 4000   CONTINUE
            NT = N3
            N3 = N4
            N4 = NT
        IF ( APROB .NE. PRINT ) GO TO 4060
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      PRINT 98
         DO 4050 JJ = 1,NM
            ISTT = IST(JJ)
         IF ( ISTT .EQ. 0 ) GO TC 4050
      PRINT 99, ( SMC(JJ,I), I=1,21), ( FOMM(JJ,I), I=1,6 )
 4050    CONTINUE
      PRINT 98
 4060    CONTINUE
         DO 4200 I = 1,NJT
      CALL      DYSTLD (FJX,FJY,FJZ,FJV,TIME2,I)
            DFJXT(I) = FJX - FJXT(I)
            DFJYT(I) = FJY - FJYT(I)
            DFJZT(I) = FJZ - FJZT(I)
            DFJVT(I) = FJV - FJVT(I)
 4200    CONTINUE
         IF (JT .GT. 1) GO TO 4260
         IF (NSMJ .EQ. 0) GO TO 4260
         DO 4250 II = 1,NSMJ
            MJOINT = MJ(II)
            II4 = II*4
            DISJT(II4-3,JT) = DXX(MJOINT)
            DISJT(II4-2,JT) = DYY(MJOINT)
            DISJT(II4-1,JT) = DZZ(MJOINT)
            DISJT(II4  ,JT) = DVV(MJOINT)
 4250    CONTINUE
 4260    CONTINUE
            J = 0
         DO 4270 I = 1,NJT
            J = J + 1
            AA = ACCJT(J)
            VV = VELJT(J)
            DFFS(1,I) = ZMASSB(J)*(2.0*AA+VV*DSS1)+DFJXT(I)
     2      +CDAMP(J)*2.0*VV
            J = J + 1
            AA = ACCJT(J)
            VV = VELJT(J)
            DFFS(2,I) = ZMASSB(J)*(2.0*AA+VV*DSS1)+DFJYT(I)
     2      +CDAMP(J)*2.0*VV
            J = J + 1
            DFFS(3,I) = DFJZT(I)
            IF (JST(I) .NE. 0) J = J + 1
            DFFS(4,I) = DFJVT(I)
 4270    CONTINUE
COMMENT - SET CONTRCL CONSTANTS FCR FRAME SOLUTION
            IHB = 4*IDJ + 3
COMMENT - CALCULATE THE NUMBER OF DEGREES OF FREEDOM
            NL = 3*NJT
         DO 4275 I=1,NJT
         IF (JST(I) .NE. 0) NL=NL+1
 4275    CONTINUE
            ML = 1
            NFSUB = 23
      CALL      GRIP2A (RM,RO,W,SL,L3,L4,L6,IHB)
         IF ( IHB .LT. 10000 ) GC TO 4280
COMMENT - SYMBOLICALLY MAKE NJNC = 1
            NJNC = 1
            IABAN = 1
            NTEMP = JT + 1
            TEMP  = TIME + DTI
      PRINT 94, NTEMP, TEMP
      GO TO 3870
 4280    CONTINUE
COMMENT - COMPUTE INCREMENTS OF VELOCITY AND ACCELERATION
         DO 4300 I = 1,NJTT
            DVELJT(I) = -2.0*VELJT(I) + 2.0*W(I)/DTI
            DACCJT(I) = -2.0*ACCJT(I) - 4.0*VELJT(I)/DTI + DSS2*W(I)
 4300    CONTINUE
         DO 4400 I = 1,NJTT
            VELJT(I) = VELJT(I) + DVELJT(I)
            ACCJT(I) = ACCJT(I) + DACCJT(I)
            DELWJT(I) = W(I)
 4400    CONTINUE
            J = 0
         DO 4500 I = 1,NJT
            J = J + 1
            DXX(I) = DXX(I) + W(J)
            J = J + 1
            DYY(I) = DYY(I) + W(J)
            J = J + 1
            DZZ(I) = DZZ(I) + W(J)
         IF (JST(I) .NE. 0) GO TO 4410
            DVV(I) = 0.0
         GO TO 4500
 4410       J = J + 1
            DVV(I) = DVV(I) + W(J)
 4500    CONTINUE
            JTP1 = JT + 1
         IF (NSMJ .EQ. 0) GO TO 4610
         DO 4600 II = 1,NSMJ
            MJOINT = MJ(II)
            II4 = II*4
            DISJT(II4-3,JTP1) = DXX(MJOINT)
            DISJT(II4-2,JTP1) = DYY(MJOINT)
            DISJT(II4-1,JTP1) = DZZ(MJOINT)
            DISJT(II4  ,JTP1) = DVV(MJOINT)
 4600    CONTINUE
```

```
 4610      CONTINUE
      GO TO 10000
 5100      CONTINUE
           IF (JT .NE. 1) GO TO 5110
                IABAN = 1
      PRINT 92, JT, TIME
      PRINT 260
                 GO TO 11100
 5110            CONTINUE
COMMENT - ITERATE WITHIN TIME STEP
COMMENT - ZERO DPFS - ONLY SOLVING FOR ERROR
           DO 5150 I = 1,NJT
                DPFS(1,I) = 0.0
                DPFS(2,I) = 0.0
                DPFS(3,I) = 0.0
                DPFS(4,I) = 0.0
 5150      CONTINUE
           DO 5155 JJ = 1,NM
           DO 5155  I = 1,6
                FOMM(JJ,I) = 0.0
 5155      CONTINUE
COMMENT - SET CONTROL CONSTANTS FOR FRAME SOLUTION
                IHB = 4*IDJ + 3
COMMENT - CALCULATE THE NUMBER OF DEGREES OF FREEDOM
                NL = 3*NJT
           DO 5158 I=1,NJT
           IF (JST(I) .NE. 0) NL=NL+1
 5158      CONTINUE
                ML = 1
                NFSUB = 23
      CALL GRIP2A (KM,KO,W,SL,L3,I4,L6,IHB)
           IF ( IHB .LT. 10000 ) GC TO 5160
COMMENT - SYMBOLICALLY MAKE NJNC = 1
                NJNC = 1
                IABAN = 1
      PRINT 92, JT, TIME
           IF ( JT .EQ. 1 ) GO TO 11100
      GO TO 3870
 5160      CONTINUE
           DO 5200 I = 1,NJTT
                VELJT(I) = VELJT(I) + W(I)*2.0/DTI
                ACCJT(I) = ACCJT(I) + W(I)*DSS2
 5200      CONTINUE
                J = 0
           DO 5300 I = 1,NJT
                J = J + 1
                DXX(I) = DXX(I) + W(J)
                J = J + 1

                DYY(I) = DYY(I) + W(J)
                J = J + 1
                DZZ(I) = DZZ(I) + W(J)
           IF (JST(I) .NE. 0) GO TC 5210
                DVV(I) = 0.0
           GO TO 5300
 5210           J = J + 1
                DVV(I) = DVV(I) + W(J)
 5300      CONTINUE
           IF (NSMJ .EQ. 0) GO TO 5410
           DO 5400 II = 1,NSMJ
                MJOINT = MJ(II)
                II4 = II*4
                DISJT(II4-3,JT) = DXX(MJOINT)
                DISJT(II4-2,JT) = DYY(MJOINT)
                DISJT(II4-1,JT) = DZZ(MJOINT)
                DISJT(II4  ,JT) = DVV(MJOINT)
 5400      CONTINUE
 5410      CONTINUE
           IF ( NITF .LT. MNITF ) GO TO 1065
      PRINT 20,MNITF
COMMENT - SYMBOLICALLY MAKE NJNC = 1
                NJNC = 1
                IABAN = 1
      PRINT 92, JT, TIME
           IF ( JT .EQ. 1 ) GO TO 11100
      GO TO 3870
10000      CONTINUE
           IF ( JT .LT. NTI1 ) GO TO 1040
                ANTI1 = NTI1
           IF ( APROB .NE. SAVE ) GO TO 10005
      WRITE (14,12)  ( AN1(II), II=1,40 )
10005      CONTINUE
           IF (NSMM .EQ. 0) GO TO 10150
           DO 10100 II = 1,NSMM
      PRINT 205, MM(II)
           IF ( APROB .NE. SAVE ) GO TO 10010
      WRITE (14,206) MM(II)
10010      CONTINUE
      PRINT 210
      PRINT 212
                TEMP = TIME - ANTI1 * DTI
           DO 10020 J = 1,NTI1
                TEMP = TEMP + DTI
      PRINT 254, J,TEMP,FRMAXF(II,J),FRMAXD(II,J),FRMMOM(II,J),
     2               FRMROT(II,J),FRMSHF(II,J),FRMLTD(II,J)
           IF ( APROB .NE. SAVE ) GO TO 10020
      WRITE (14,255) MM(II),J,TEMP,FRMAXF(II,J),FRMAXD(II,J),
```

```
     2                        FRMMOM(II,J),FRMROT(II,J),FRMSHF(II,J),FRMLTD(II,J)
10020     CONTINUE
      PRINT 205, MM(II)
          IF ( APROB .NE. SAVE ) GO TO 10022
      WRITE (14,207) MM(II)
10022     CONTINUE
      PRINT 211
      PRINT 212
                TEMP = TIME - ANTI1 * DTI
          DO 10024 J = 1,NTI1
                TEMP = TEMP + DTI
      PRINT 254, J,TEMP,TOAXF(II,J),TOAXD(II,J),TOMOM(II,J),
     2                   TOROT(II,J),TOSHF(II,J),TOLTD(II,J)
          IF ( APROB .NE. SAVE ) GO TO 10024
      WRITE (14,255) MM(II),J,TEMP,TOAXF(II,J),TOAXD(II,J),
     2                TOMOM(II,J),TOROT(II,J),TOSHF(II,J),TOLTD(II,J)
10024     CONTINUE
      PRINT 220, MM(II)
          IF ( APROB .NE. SAVE ) GO TO 10030
      WRITE (15,221) MM(II)
10030     CONTINUE
                TEMP = TIME - ANTI1 * DTI
                ISTT = IST(MM(II))
          IF (ELEMN(ISTT) .EQ. SHEAR) GO TO 10060
      PRINT 251
      PRINT 230
          DO 10050 J = 1,NTI1
                TEMP = TEMP + DTI
      PRINT 254, J,TEMP,FORCEL(II,J),STRANL(II,J),
     2                   BMOMNL(II,J),CURVAL(II,J)
          IF ( APROB .NE. SAVE ) GO TO 10050
      WRITE (15,255) MM(II),J,TEMP,FORCEL(II,J),STRANL(II,J),
     2                                 BMOMNL(II,J),CURVAL(II,J)
10050     CONTINUE
      PRINT 220, MM(II)
          IF ( APROB .NE. SAVE ) GO TO 10052
      WRITE (15,222) MM(II)
10052     CONTINUE
                TEMP = TIME - ANTI1 * DTI
      PRINT 252
      PRINT 230
          DO 10054 J = 1,NTI1
                TEMP = TEMP + DTI
      PRINT 254, J,TEMP,FORCER(II,J),STRANR(II,J),
     2                   BMOMNR(II,J),CURVAR(II,J)
          IF ( APROB .NE. SAVE ) GO TO 10054
      WRITE (15,255) MM(II),J,TEMP,FORCER(II,J),STRANR(II,J),
     2                                 BMOMNR(II,J),CURVAR(II,J)
10054     CONTINUE
          GO TO 10100
10060     CONTINUE
      PRINT 251
      PRINT 253
          DO 10070 J = 1,NTI1
                TEMP = TEMP + DTI
      PRINT 254,J,TEMP,FORCEL(II,J),STRANL(II,J),
     2    BMOMNL(II,J),CURVAL(II,J),SHFORL(II,J),GAMMAL(II,J)
          IF (APROB .NE. SAVE) GO TO 10070
      WRITE (15,255) MM(II),J,TEMP,FORCEL(II,J),STRANL(II,J),
     2    BMOMNL(II,J),CURVAL(II,J),SHFORL(II,J),GAMMAL(II,J)
10070     CONTINUE
      PRINT 220, MM(II)
          IF ( APROB .NE. SAVE ) GO TO 10072
      WRITE (15,222) MM(II)
10072     CONTINUE
                TEMP = TIME - ANTI1 * DTI
      PRINT 252
      PRINT 253
          DO 10080 J = 1,NTI1
                TEMP = TEMP + DTI
      PRINT 254, J,TEMP,FORCER(II,J),STRANR(II,J),
     2    BMOMNR(II,J),CURVAR(II,J),SHFORR(II,J),GAMMAR(II,J)
          IF (APROB .NE. SAVE) GO TO 10080
      WRITE (15,255) MM(II),J,TEMP,FORCER(II,J),STRANR(II,J),
     2    BMOMNR(II,J),CURVAR(II,J),SHFORR(II,J),GAMMAR(II,J)
10080     CONTINUE
10100     CONTINUE
10150     CONTINUE
      PRINT 11
      PRINT 110, TIME
      PRINT 100, ( DXX(I), DYY(I), DZZ(I), DVV(I), I=1,NJT )
      PRINT 90
      PRINT 120, TIME
                J = 0
          DO 10160 I = 1,NJT
                J = J + 1
                VV1 = VELJT(J)
                J = J + 1
                VV2 = VELJT(J)
                J = J + 1
                VV3 = VELJT(J)
          IF (JST(I) .NE. 0) GO TO 10158
                VV4 = 0.0
          GO TO 10159
10158           J = J + 1
                VV4 = VELJT(J)
```

```
10159       CONTINUE
      PRINT 100, VV1,VV2,VV3,VV4
10160       CONTINUE
      PRINT 90
      PRINT 130, TIME
              J = 0
         DO 10170 I = 1,NJT
              J = J + 1
              AA1 = ACCJT(J)
              J = J + 1
              AA2 = ACCJT(J)
              J = J + 1
              AA3 = ACCJT(J)
         IF (JST(I) .NE. 0) GO TO 10168
              AA4 = 0.0
         GO TO 10169
10168         J = J + 1
              AA4 = ACCJT(J)
10169    CONTINUE
      PRINT 100, AA1,AA2,AA3,AA4
10170    CONTINUE
         IF (NSMJ .EQ. 0) GO TO 11000
         DO 10600 II = 1,NSMJ
              I = MJ(II)
              II4 = II*4
         DO 10200 J = 1,NTI1
         IF ( II .EQ. 1) GO TO 10190
         IF (MJO - 1) 10190,10180,10175
10175         TR(J) = DISJT(II4-3,J) - DISJT(II4-7,J)
         GO TO 10200
10180         TR(J) = DISJT(II4-3,J) - DISJT(1,J)
         GO TO 10200
10190         TR(J) = DISJT(II4-3,J)
10200    CONTINUE
      CALL        CSPLOT (TR,1,I,TIME,II)
         DO 10300 J = 1,NTI1
         IF ( II .EQ. 1) GO TO 10290
         IF (MJO - 1) 10290,10280,10270
10270         TR(J) = DISJT(II4-2,J) - DISJT(II4-6,J)
         GO TO 10300
10280         TR(J) = DISJT(II4-2,J) - DISJT(2,J)
         GO TO 10300
10290         TR(J) = DISJT(II4-2,J)
10300    CONTINUE
      CALL        CSPLOT (TR,2,I,TIME,II)
         DO 10400 J = 1,NTI1
         IF ( II .EQ. 1) GO TO 10390
         IF (MJO - 1) 10390,10380,10370
10370         TR(J) = DISJT(II4-1,J) - DISJT(II4-5,J)
         GO TO 10400
10380         TR(J) = DISJT(II4-1,J) - DISJT(3,J)
         GO TO 10400
10390         TR(J) = DISJT(II4-1,J)
10400    CONTINUE
      CALL        CSPLOT (TR,3,I,TIME,II)
         DO 10500 J = 1,NTI1
         IF ( II .EQ. 1) GO TO 10490
         IF (MJO - 1) 10490,10480, 10470
10470         TR(J) = DISJT(II4,J) - DISJT(II4-4,J)
         GO TO 10500
10480         TR(J) = DISJT(II4,J) - DISJT(4,J)
         GO TO 10500
10490         TR(J) = DISJT(II4,J)
10500    CONTINUE
      CALL CSPLOT (TR,4,I,TIME,II)
         DO 10520 J = 1,NTI1
              TR(J) = SHMJT(II,J)
10520    CONTINUE
      CALL        CSPLOT (TR,5,I,TIME,II)
         IF ( APROE .NE. SAVE ) GO TO 10540
      WRITE (16,256) MJ(II)
              TEMP = TIME - ANTI1 * DTI
         DO 10530 J = 1,NTI1
              TEMP = TEMP + DTI
      WRITE (16,257) MJ(II),J,TEMP,DISJT(II4-3,J),DISJT(II4-2,J),
     2   DISJT(II4-1,J),DISJT(II4,J),SHMJT(II,J)
10530    CONTINUE
10540    CONTINUE
10600    CONTINUE
11000    CONTINUE
         IF ( IABAN .EQ. 1 ) NTR = NTR + 1
         IF ( IABAN .EQ. 0 ) GO TO 11100
         IF ( NTR .EQ. 0 .OR. NTR .GT. NTRA ) GO TO 11100
              DTI = DTI * 0.5
              TEMP = ( TOTTME - TIME ) / DTI
              NTI = TEMP
              ITYPE = 4
      PRINT 200
      GO TO 900
11100    CONTINUE
      RETURN
      END
```

```
************************************ SUBROUTINE ************************************
      SUBROUTINE ADDYN2 (JTN,FSS)
COMMENT - SUBROUTINE ADDYN2, CALLED BY SUBROUTINE DYNAJS, ADDS THE
COMMENT - CONTRIBUTION DUE TO MASS AND DAMPING TO STIFFNESS MATRIX TO
COMMENT - OBTAIN INCREMENTAL JOINT DISPLACEMENT USING CONSTANT AVERAGE
COMMENT - ACCELERATION METHOD.
      IMPLICIT REAL*8 (A-H,O-Z)
      DIMENSION FSS(4)
      COMMON /BALA02/ JST(25),NJSS(25),HLJ(25),HRJ(25),VLJ(25),VUJ(25),
     2    THKJ(25),GJ(25),SJC(25)
      COMMON /BLOC10/ SSL(4,24)
      CCMMON /BLOC21/ ACCJT(100),VELJT(100),ZMASSR(100),DACCJT(100),
     2    DVELJT(100),FACCJT(100),FDAMJT(100),CDAMP(100),DISJT(80,71)
      COMMON /BLOC23/ DFFS(4,25)
      COMMON/ITC/ ERR1,ERR2,ER1,ER2,DTI,CM,NTI,MM(20),MJ(20),MNITF,
     2            MNITM,NSMJ,NSMM
            DSS2=4.0/DTI**2
            DSS12=2.0/DTI
            J = 3*JTN
        DO 100 I = 1,JTN
        IF (JST(I) .NE. 0) J = J + 1
  100   CONTINUE
            IL = 3
        IF (JST(JTN) .NE. 0) IL = 4
        DO 200 I = 1,IL
            ITEMP=J-IL+I
  200       SSL(I,I) = SSL(I,I)+DSS2*ZMASSR(ITEMP)
     2      +DSS12*CDAMP(ITEMP)
        DO 300 I = 1,IL
  300       FSS(I) = FSS(I) + DFFS(I,JTN)
      RETURN
      END
```

APPENDIX G
SAMPLE INPUT

```
EXAMPLE 8.4 - CANTILEVERED BEAM W 14X142 WITH DYNAMIC LOAD BUT NO MASS,
AT THE FREE END. JSYES OPTION AND NONLINEAR STRESS-STRAIN CURVE FOR JOINT.
    1PDNO JSYES LOAD INCREMENT (STATIC)
    1

        2     5     2     2     2      0      0      0     0     2     0     0     0     0     2
              2           1      0.0           0.0                           0.001
              1     100.0        0.0                      2
    2
    0         2
    1         1
    1    15 0       0 0      6,84      6 84      0 680                              1
    0
0.01     1     3      1                        0 2078  3013
         0.000001                              0 1807  7228
              1          0
         1          1    0         2
    1
         1.00E+20    1.00E+20   1.00E+20
    2              0.0
    1   2030000.0    SHEAR      1660.0     41.54                 1     1
11500,0   8.58
              10    400.001     0.01       0.01                  2     1     2
                    100.0001    0.001                            1     1
    1PDNO JSYES 2ND LOAD INCREMENT (DYNAMIC)
     3    1     1    1     1    1     1    1    1     1     1     1     1     1     1     1
    10   10    10
                                               1     2
          2           1,0                                 0.1                     1
          1     4                  0   -40    40    0
                                   0     1     3    4

EXAMPLE 9.2 - BERKELEY 1-BAY 3-STORY FRAME OF R.W.CLOUGH AND D.T TANG;
JOINT & MEMBER SHEARS ARE INCLUDED; EC400-I EARTHQUAKE:
   921      JSYES STATIC ANALYSIS                                                 SAVE
     9

         6    5     2     8     8      0      0      0     0     6     8     12     0    12     2
              8           1      0.0           0.0                           0.001
              1     144.0        0.0                      2
              1     0.0          80.0                     3
              3     0.0          64.0                     5     7
              2     0.0          80.0                     4
              4     0.0          64.0                     6     8
    2
    0
    1         1     2
    0         3     4     5     6     7     8
    1
    1    2.3005      2.3005      2.8735      2.8735     0.246                          1
         1     3     1                           0     255    472
0.1           1.0E-05                            0     219   1314
               3
         1          1      3
         3          2      0          3     7
         2          1      0          5
         4          2      0          4     8
         3          3      1          6
         5          3      2          4
         7          3      3          6
                                      8
    1
    2     1.0E+20     1.0E+20     1.0E+20                                  1.0E+20
    3     1.0E+20     1.0E+20     1.0E+20                                  1.0E+20
    4                                                                    0.006011
    5                                                                    0.006011
    6                                                                    0.006009
    7                                                                    0.006009
    8                                                                    0.006017
                                                                         0.006017
    1   10     1     SHEAR                        1          1     1     1
    2    8           SHEAR                        1          1     1     1
    3   16     1     SHEAR                        1          1     1     1
               2                                  2
         1     3
      25,00         0.367      2.3005                 10. 1            1,0E-050,0
      40.246        4.234      0.0                    20. 1            1.0E-051.0
      25.00         0.367     -2,3005                 10. 1            1,0E-050,0
         2     3
      24.016        0.284      2.8735                 30. 1            1,0E-050.0
      40.243        5.463      0.0                    40. 1            1.0E-051.0
      24.016        0.284     -2,8735                 30. 1            1.0E-050,0
         1     4     1                       0   398    398    654
```

```
                                                            0   134  1970  5910
11460.0
           2     4     1                                    0   441   441   650
                                                            0   146  2700  7050
11650.0
           3     4     1                                    0   392   392   636
                                                            0   127  1520  4840
11850.0
           4     4     1                                    0   496   496   676
                                                            0   161  2450  6120
11880.0
           1                                                                     3     1
            0.0          139.399                 -0.00441
            45.6995      45.6995                 -2.015
            93.6995      93.6995                 -2.015
           2                                                                     3     1
            0.0          139.399                 -0.00426
            45.6995      45.6995                 -2.025
            93.6995      93.6995                 -2.025
           3                                                                     3     1
            0.0          139.399                 -0.00380
            45.6995      45.6995                 -2.06
            93.6995      93.6995                 -2.06
                 10     200.01       0.1         0.012                           8     2     4     6     8
     1     3      5      7
 0.042             1    100.001      0.01                                        9     1     2     3     4
     5     6      7      8     9
   922      JSYES DYNAMIC ANALYSIS - EC400-I INPUT                                                    SAVE
     4     1      1      1     1     1     1     1     1     1     1     1     1     1     1     1
    10    10     10
                                     2                 2     2
     1
              -1.0E+20
     2
              -1.0E+20
           1 3.864E+18                                             0.001             1
           2 3.864E+18                                             0.001             1
           1  218                 112    66  -448   736  -163   341  -118   413  -454   -93   560
  -442   -33  332  -464   420     -70   182  -631   323  -427   423  -743   526  -442   345  -818
   498  -885  520  -774   609    -508   547  -592   793  -541   600  -558   673  -530   790  -743
   776  -799  806  -749   770    -608   866  -600   875  -636   970  -583   758  -577   458  -745
   969  -979  910  -272   105    -750   789  -415   509  -388  -515  -119  -710   455-1234   194
  -484   723 1537  -437  -590-1249  -435  -566  -126  -388  1872  3278  1280  2730   402  1479
 -1045-5349-3461-1594-1704  1721  3675   425-3592  3653-1726  1084  1896  -474   645-2385
    75   448-2603   800-1878  -910   538-2227  2604-1236  3397-1980  1402-1055-1405  1230
 -3115   641 -258   467  1018-1592  -492-1721  3157  -243  2745  1320-3618  2048-4096  1439
  1618   280 2543  -594   637      45   507-2082  1497-2694   841-3417   403  -694   -57  -562
  1479  -474 1479-1968  1565  -587  1452-1358  1559  -616   195    -4   587  -425  1460-1594
  1038  -920 -243  -511  1636-1068  1145-1955   303   936-1527  1082-1645   502   280   521
  -402  -317  624-1619  1274-1077  1007  1466  -665  1506  -580   890  -580   -74  -951   191
  -858    45   93  2186  -664   -62  -497  -184-2939  1616  -709  1501-2009  -925-1739
                                  0   110   169   213   258   309   361   405   442   478
   545   574  603   633   699   743   802   817   898   935   994  1030  1097  1126  1207  1229
  1295  1332 1391  1428  1494  1538  1590  1627  1685  1752  1781  1832  1884  1921  1987  2017
  2090  2134 2193  2230  2289  2340  2392  2443  2502  2546  2598  2664  2701  2753  2797  2863
  2900  2966 3010  3062  3121  3143  3194  3231  3305  3341  3459  3503  3547  3621  3658  3717
  3753  3790 3834  3864  3937  3930  4018  4085  4129  4217  4261  4283  4342  4386  4438  4504
  4548  4607 4637  4666  4740  4784  4857  4945  5005  5093  5174  5225  5277  5343  5402  5454
  5520  5579 5638  5696  5763  5807  5873  5939  6006  6108  6190  6248  6322  6366  6425  6491
  6550  6616 6661  6712  6778  6845  6896  6948  7073  7146  7205  7293  7330  7403  7485  7588
  7676  7735 7794  7868  7919  7963  8007  8066  8125  8206  8294  8361  8434  8471  8493  8537
  8604  8670 8707  8773  8832  8920  9008  9052  9126  9170  9207  9251  9295  9347  9391  9465
  9509  9590 9641  9730  9788  9847  9906  99871000910075101421019310259103181034010370
 10399104291048010547106051067210701107531081910907109811102511069111211115711209
 11275113121136311430114661153311555115921165011702117981184911923119451200
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APPENDIX H
SAMPLE OUTPUT

```
EXAMPLE 8.4 - CANTILEVERED BEAM W14X142 WITH DYNAMIC LOAD BUT NO MASS,       I-----TPIN
AT THE FREE END. JSYES OPTION AND NONLINEAR STRESS-STRAIN CURVE FOR JOINT.
```

I-----TRIM

NOTE - THIS PROBLEM ANALYZED EXCLUDING ALL GEOMETRIC NONLINEARITIES - ALL FOLLOW UP PROBLEMS SHOULD BE ANALYZED WITH SAME PDNO OPTION

NOTE - THIS ANALYSIS INCLUDES SHEAR DEFORMATION AT THE JOINTS. ALL FOLLOW UP PROBLEMS SHOULD BE ANALYZED WITH THE SAME JSYES OPTION

EXAMPLE B.4 - CANTILEVERED BEAM W14X142 WITH DYNAMIC LOAD BUT NO MASS, AT THE FREE END. JSYES OPTION AND NONLINEAR STRESS-STRAIN CURVE FOR JOINT.

PROB

1PDNO JSYES LOAD INCREMENT (STATIC)

TABLE 1 - PROGRAM CONTROL DATA
PROBLEM TYPE 1

INPUT TABLES

TABLE NUMBER	HOLD DATA FROM LAST PROBLEM (1 = YES, 0 = NO)	NUMBER OF CARDS ADDED FOR THIS PROBLEM
2	0	2
3A	0	5
3B	0	2
3C	0	2
4A	0	2
4B	0	0
4C	0	0
4D	0	0
4E	0	0
5A	0	2
5B	0	0
5C	0	0
5D	0	0
6	0	0
7	0	2

OUTPUT TABLES

TABLE NUMBER	SUPRESS OUTPUT (1 = YES, 0 = NO)
8	0
9	0
10	0

I-----TRIM

PROB 1 (CONTD)   LOAD INCREMENT (STATIC)

TABLE 2 - FRAME GEOMETRY DATA

```
NUMBER OF JOINTS IN FRAME =    2
REFERENCE JOINT IS JOINT       1  AT  X  =   0.0       AND Y =   0.0
JOINT TOLERANCE IS      0.100D-02
```

INPUT OF JOINT OFFSETS

FROM JOINT	X-OFFSET	Y-OFFSET	TO JOINT	TO	TO	TO	TO	TO	TO
1	0.1000+03	0.0	2						

COMPUTED JOINT COORDINATES

JOINT	X	Y
1	0.0	0.0
2	0.100D+03	0.0

I-----TRIM

PROB$_1$ (CONTD)   LOAD INCREMENT (STATIC)

TABLE 3A - JOINT TYPE AND SIZE DATA

NUMBER OF JOINT STIFFNESS TYPES = 2

JOINT TYPE	JOINTS
0	2
1	1

JOINT STIFF TYPE	HLJ	HRJ	VLJ	VUJ	THKJ	GJ	NJSS
1	0.150D+02	0.0	0.684D+01	0.684D+01	0.680D+00	0.0	1
0	0.0	0.0	0.0	0.0	0.0	0.0	0

TABLE 3B - JOINT SHEAR STRESS STRAIN CURVES

MATE RIAL	CURVE NUMB	NUMB PTS	SYMT OPT (1=YES, 0 = NO)	TAU-MULT	GAM-MULT
-	1	3	1	0.100D-01	0.100D-05

TAU   0 2078 3013

GAM   0 1807 7228

DETAILS OF BASIC STRESS-STRAIN CURVES
SCALING FACTORS EXCLUDED

CURVE NUMBER = 1   # OF COMPONENT SPRINGS = 2

STRAINS INPUT (INTEGERS)	STRESSES INPUT (INTEGERS)	STIFFNESS OF COMPONENTS (UNSCALED)	MAX STRESS OF COMPONENTS (UNSCALED)
0.0	0.0		
1807.0000	2078.0000	0.9775	1766.3333
7228.0000	3013.0000	0.1725	1246.6667

DEGRADATION ALPHJ	YIELD GROWTH BETJ
0.0	0.0

TABLE 3C - MEMBER LOCATION DATA

NUMBER OF MEMBER STIFFNESS TYPES = 1
NUMBER OF MEMBER LOAD TYPES = 0

INPUT OF MEMBER LOCATIONS

FROM JOINT	STIFF TYPE	LOAD TYPE	TO JOINT	TO	TO	TO	TO	TO	TO	TO	TO	TO
1	1	0	2									

COMPUTED MEMBER NUMBERS, LENGTHS, AND OFFSETS

MEMBER NUMB	FROM JOINT	TO JOINT	STIFF TYPE	LOAD TYPE	LENGTH	X-OFFSET	Y-OFFSET
1	1	2	1	0	0.100D+03	0.100D+03	0.0

*** COMPUTED MEMBER NUMBERS MAY NOT AGREE WITH LAST PROBLEM ***

I-----TRIM

PROB 1 (CONTD)   LOAD INCREMENT (STATIC)

TABLE 4A - JOINT LOADS AND LINEAR RESTRAINTS

INPUT OF JOINT DATA

JOINT	FORCE(X)	FORCE(Y)	MOMENT(Z)	MOMENT(Y)	SPRING(X)	SPRING(Y)	SPRING(Z)	SPRING(Y)	MASS
1	0.0	0.0	0.0	0.0	0.100D+21	0.100D+21	0.100D+21	0.0	0.0
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

ACCUMULATED JOINT DATA

SAME AS INPUT FOR THIS PROBLEM

TABLE 4B - JOINT SUPPORT CURVE NUMBERS

NO DATA

TABLE 4C - JOINT SUPPORT CURVES

NO DATA

TABLE 4D - TIME VARYING JOINT LOADS - CURVE   NUMBERS AND MULTIPLIERS

NO DATA

TABLE4E - TIME VARYING JOINT LOAD CURVES

NO DATA

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$PROB_1$ (CONTD) LOAD INCREMENT (STATIC)

TABLE 5A - MEMBER STIFFNESS DATA

STIF TYPE	#OF ELEM	MOD OF ELAST	ELEMENT TYPE	PRISMATIC I	PRISMATIC A	NON LIN	NUMB CRDS	AXIS OPT	OUTPUT OPT	PIN FROM	PIN TO
1	20	0.300D+05	SHEAR	0.166D+04	0.415D+02	0	1	1	0	0	0

MOD OF RIGIDITY	PRISMATIC SHR.AREA
0.115D+05	0.858D+01

TABLE 5B - CROSS SECTION DATA

NO DATA IN TABLE

TABLE 5C - STRESS STRAIN CURVES

NO DATA IN TABLE

TABLE 5D - SUPPORT CURVES FOR MEMBERS

NO DATA IN TABLE

I-----TRIM

PROB$_1$ (CONTD)   LOAD INCREMENT (STATIC)

TABLE 6 - MEMBER LOAD DATA

NO DATA

I-----TRIM

PROB 1 (CONTD) LOAD INCREMENT (STATIC)

TABLE 7 - ITERATICN CONTROL

FRAME SOLUTION

LOAD NRED	TIME NRED	NUMB ITER	NUMB STEPS	FORCE ERROR	MOMENT ERROR	LENGTH OF TIME STEP	JNT.LOAD RED.PRCNT	NO.OF MON JOINTS
0	0	10	40	0.100D-02	0.100D-01	0.100D-01	0.0	2

MONITOR JOINTS

1	2	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0

MONITCR JCINT OUTPUT OPTION = 0

DAMPING AND MEMBER SOLUTIONS

DAME COEFF	MONITOR JOINT OPT	NUMB ITER	FORCE ERROR	MOMENT ERROR	MEM.LOAD RED.PRCNT	NO.OF MON MEMBERS
0.0	0	10	0.100D-03	0.100D-02	0.0	1

MONITOR MEMBERS

1	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0

SUMMARY OF FRAME ITERATIONS

NO	JOINT ITER	FRAME DISP(X)	JOINT DISPLACEMENTS DISP(Y)	ROT(Z)	ROT(Y)	ERR(X)	JOINT EQUILIBRIUM ERRORS ERR(Y)	ERR(Z)	ERR(Y)
1	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

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PROB 1 (CONTD)   LOAD INCREMENT (STATIC)

TABLE 8 - JOINT DISPLACEMENTS, REACTIONS AND SHEAR PANEL INTERNAL MOMENTS

JNT	DISP(X)	DISP(Y)	ROT(Z)	ROT(V)	REACT(X)	REACT(Y)	REACT(Z)	REACT(V)	SHR.MOM(Z)	SHR MOM(V)
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
				TOTAL	0.0	0.0	0.0	0.0		

PROB 1 (CONTD)   LOAD INCREMENT (STATIC)   I-----TRIM

TABLE 9 - MEMBER RESULTS

MEMBER NUMBER 1

MEMBER LENGTH 100.000   NUMBER OF ELEM 20   ELMNT LNGTH 5.0000

MEMBER NUMBER 1   STIFF TYPE 1   LOAD TYPE 0
LENGTH = 0.100D+03   ALPHA = 0.100D+01   BETA = 0.0
GOES FROM JOINT 1 TO JOINT 2
OUTPUT DISTANCES ARE FROM JOINT 1 ALONG THE MEMBER AXIS
ALL OUTPUT FORCES AND DISPLACEMENTS ARE WITH RESPECT TO THE MEMBER AXES

	DISPLACEMENTS			FORCES			
DISTANCE	AXIAL	LATERAL	ROTATIONAL	AXIAL	SHEAR	MOMENT	IXXXXIXXXXIXXXXIXXXXIXXXXIXXXXIXXXXIXXXXI
0.0	0.0	0.0	0.0	0.0	0.0	0.0	*
5.000D+00	0.0	0.0	0.0	0.0	0.0	0.0	*
1.000D+01	0.0	0.0	0.0	0.0	0.0	0.0	*
1.5000+01	0.0	0.0	0.0	0.0	0.0	0.0	*
2.0000+01	0.0	0.0	0.0	0.0	0.0	0.0	*
2.500U+01	0.0	0.0	0.0	0.0	0.0	0.0	*
3.000D+01	0.0	0.0	0.0	0.0	0.0	0.0	*
3.500D+01	0.0	0.0	0.0	0.0	0.0	0.0	*
4.0000+01	0.0	0.0	0.0	0.0	0.0	0.0	*
4.5000+01	0.0	0.0	0.0	0.0	0.0	0.0	*
5.0000+01	0.0	0.0	0.0	0.0	0.0	0.0	*
5.500U+01	0.0	0.0	0.0	0.0	0.0	0.0	*
6.000D+01	0.0	0.0	0.0	0.0	0.0	0.0	*
6.500D+01	0.0	0.0	0.0	0.0	0.0	0.0	*
7.0000+01	0.0	0.0	0.0	0.0	0.0	0.0	*
7.5000+01	0.0	0.0	0.0	0.0	0.0	0.0	*
8.000D+01	0.0	0.0	0.0	0.0	0.0	0.0	*
8.500D+01	0.0	0.0	0.0	0.0	0.0	0.0	*
9.000D+01	0.0	0.0	0.0	0.0	0.0	0.0	*
9.5000+01	0.0	0.0	0.0	0.0	0.0	0.0	*
1.000D+02	0.0	0.0	0.0	0.0	0.0	0.0	*

ELEM NUMB	AXIAL FORC	AXIAL STRAIN	BEND MOMENT	CURVATURE	SHEAR FORCE	SHEAR STRAIN
2	0.0	0.0	0.0	0.0	0.0	0.0
3	0.0	0.0	0.0	0.0	0.0	0.0
4	0.0	0.0	0.0	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0	0.0	0.0
6	0.0	0.0	0.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0	0.0	0.0
12	0.U	0.U	0.0	0.0	0.0	0.0
13	0.0	0.0	0.0	0.0	0.0	0.0
14	0.0	0.0	0.0	0.0	0.0	0.0
15	0.0	0.0	0.0	0.0	0.0	0.0
16	0.0	0.0	0.0	0.0	0.0	0.0
17	0.0	0.0	0.0	0.0	0.0	0.0
18	0.0	0.0	0.0	0.0	0.0	0.0
19	0.0	0.0	0.0	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0	0.0	0.0
21	0.0	0.0	0.0	0.0	0.0	0.0

I-----TRIM

PROB 1 (CONTD)   LOAD INCREMENT (STATIC)

TABLE 10 - JOINT EQULIBRIUM ERRORS

JOINT	ERR(X) FORCE	ERR(Y) FORCE	ERR(Z) MOMENT	ERR(V) MOMENT
1	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0

EXAMPLE 8.4 - CANTILEVERED BEAM W14X142 WITH DYNAMIC LOAD BUT NO MASS, AT THE FREE END. JSYES OPTION AND NONLINEAR STRESS-STRAIN CURVE FOR JOINT.

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PROB

1PDNO JSYES 2ND LOAD INCREMENT (DYNAMIC)

TABLE 1 - PROGRAM CONTROL DATA
PROBLEM TYPE 3

INPUT TABLES

TABLE NUMBER	HOLD DATA FROM LAST PROBLEM (1 = YES,0 = NO)	NUMBER OF CARDS ADDED FOR THIS PROBLEM
2	1	0
3A	1	0
3B	1	0
3C	1	0
4A	1	0
4B	1	0
4C	1	0
4D	1	1
4E	1	2
5A	1	0
5B	1	0
5C	1	0
5D	1	0
6	1	0
7	1	0

OUTPUT TABLES

TABLE NUMBER	TIMESTEP INTERVALS FOR OUTPUT
8	10
9	10
10	10

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PROB (CONTD)
1
2ND LOAD INCREMENT (DYNAMIC)

TABLE 2 - FRAME GEOMETRY DATA

HOLDING DATA FROM THE PREVIOUS PROBLEM PLUS THE FOLLOWING

NCNE

COMPUTED JOINT COORDINATES

JOINT	X	Y
1	0.0	0.0
2	0.100D+03	0.0

TABLE 3A - JOINT TYPE AND SIZE DATA

HOLDING DATA FROM THE PREVIOUS PROBLEM PLUS THE FOLLOWING

NONE

TABLE 3B - JOINT SHEAR STRESS STRAIN CURVES

HOLDING DATA FROM THE PREVIOUS PROBLEM PLUS THE FOLLOWING

NCNE

TABLE 3C - MEMBER LOCATION DATA

HOLDING DATA FROM THE PREVIOUS PROBLEM PLUS THE FOLLOWING

NCNE

COMPUTED MEMBER NUMBERS,LENGTHS,AND OFFSETS

MEMBER NUMB	FROM JOINT	TO JOINT	STIFF TYPE	LOAD TYPE	LENGTH	X-OFFSET	Y-OFFSET
1	1	2	1	0	0.100D+03	0.100D+03	0.0

*** COMPUTED MEMBER NUMBERS AGREE WITH LAST PROBLEM ***

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PROB$_1$ (CONTD) 2ND LOAD INCREMENT (LYNAMIC)

TABLE 4A - JOINT LOADS AND LINEAR RESTRAINTS

HOLDING DATA FROM THE PREVIOUS PROBLEM PLUS THE FOLLOWING

NCNE

ACCUMULATED JOINT DATA

JOINT	FORCE(X)	FORCE(Y)	MOMENT(Z)	MOMENT(V)	SPRING(X)	SPRING(Y)	SPRING(Z)	SPRING(V)	MASS
1	0.0	0.0	0.0	0.0	0.100D+21	0.100D+21	0.100D+21	0.0	0.0

TABLE 4B - JOINT SUPPORT CURVE NUMBERS

HCLDING DATA FROM THE PREVIOUS PRCBLEM PLUS THE FOLLOWING

NCNE

ACCUMULATED JOINT DATA

JOINT	Q-MULT	W-MULT	NSXX NSYY NSZZ NSVV NSXP NSYP	STIFF

TABLE 4C - JOINT SUPPORT CURVES

HOLDING DATA FROM THE PREVIOUS PROBLEM PLUS THE FOLLOWING

NCNE

TABLE 4D - TIME VARYING JOINT LOADS - CURVE NUMBERS AND MULTIPLIERS

HOLDING DATA FROM THE PREVIOUS PROBLEM PLUS THE FOLLOWING

INPUT OF JOINT DATA

JCINT	FORCE(X) MULT	FORCE(Y) MULT	FORCE(Z) MULT	FORCE(V) MULT	TIME MULT	CURVE (X) NUMB	CURVE (Y) NUMB	CURVE (Z) NUMB	CURVE (V) NUMB
2	0.0	0.100D+01	0.0	0.0	0.100D+00	0	1	0	0

ACCUMULATED JOINT DATA

JOINT	FORCE(X) MULT	FORCE(Y) MULT	FORCE(Z) MULT	FORCE(V) MULT	TIME MULT	CURVE (X) NUMB	CURVE (Y) NUMB	CURVE (Z) NUMB	CURVE (V) NUMB
2	0.0	0.100D+01	0.0	0.0	0.100D+00	0	1	0	0

TABLE4E - TIME VARYING JOINT LOAD CURVES

HOLDING DATA FROM THE PREVIOUS PROBLEM PLUS THE FOLLOWING

INPUT OF JOINT DATA

ACCUMULATED JOINT DATA

CURVE NUMB	NUMB PTS				
1	4				
LOAD		0	-40	40	0
TIME		0	1	3	4

TABLE 5A - MEMBER STIFFNESS DATA

HOLDING DATA FROM THE PREVIOUS PROBLEM PLUS THE FOLLOWING

NONE

TABLE 5B - CROSS SECTION DATA

HOLDING DATA FROM THE PREVIOUS PROBLEM PLUS THE FOLLOWING

NONE

TABLE 5C - STRESS STRAIN CURVES

HOLDING DATA FROM THE PREVIOUS PROBLEM PLUS THE FOLLOWING

NONE

TABLE 5D - SUPPORT CURVES FOR MEMBERS

HOLDING DATA FROM THE PREVIOUS PROBLEM PLUS THE FOLLOWING

NONE

TABLE 6 - MEMBER LOAD DATA

HOLDING DATA FROM THE PREVIOUS PROBLEM PLUS THE FOLLOWING

NONE

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PROB$_1$ (CONTD) 2ND LOAD INCREMENT (DYNAMIC)

TABLE 7 - ITERATION CONTROL

HOLDING DATA FROM THE PREVIOUS PROBLEM

FRAME SOLUTION

LOAD NRED	TIME NRED	NUMB ITER	NUMB STEPS	FORCE ERROR	MOMENT ERROR	LENGTH OF TIME STEP	JNT.LOAD RED.PRCNT	NO.OF MON JOINTS
0	0	10	40	0.100D-02	0.100D-01	0.100D-01	0.0	2

MONITOR JOINTS

1	2	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0

MONITOR JOINT OUTPUT OPTION = 0

DAMPING AND MEMBER SOLUTIONS

DAMP COEFF	MONITOR JOINT OPT	NUMB ITER	FORCE ERROR	MOMENT ERROR	MEM.LOAD RED.PRCNT	NO.OF MON MEMBERS
0.0	0	10	0.100D-03	0.100D-02	0.0	1

MONITOR MEMBERS

1	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0

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PROB$_1$ (CONTD)   2ND LOAD INCREMENT (DYNAMIC)

RESULTS AT END OF TIME STEP =   1   AND   TIME =   0.0

TABLE 8 - JOINT DISPLACEMENTS, REACTIONS AND SHEAR PANEL INTERNAL MOMENTS

JNT	DISP(X)	DISP(Y)	ROT(Z)	ROT(V)		REACT(X)	REACT(Y)	REACT(Z)	REACT(V)	SHR MOM(Z)	SHR.MOM(V)
1	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0
					TOTAL	0.0	0.0	0.0	0.0		

PROB 1 (CONTD) 2ND LOAD INCREMENT (DYNAMIC) I-----TPIM

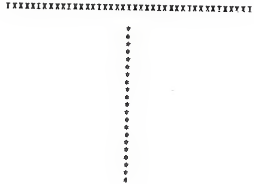
TABLE 9 - MEMBER RESULTS

MEMBER NUMBER 1 TIME STEP 1 TIME 0.0

MEMBER LENGTH 100.000 NUMBER OF ELEM 20 ELMNT LNGTH 5.0000

MEMBER NUMBER 1 STIFF TYPE 1 LOAD TYPE 0
LENGTH = 0.100D+03 ALPHA = 0.100D+01 BETA = 0.0
GOES FROM JOINT 1 TO JOINT 2
OUTPUT DISTANCES ARE FROM JOINT 1 ALONG THE MEMBER AXIS
ALL OUTPUT FORCES AND DISPLACEMENTS ARE WITH RESPECT TO THE MEMBER AXES

	DISPLACEMENTS			FORCES		
DISTANCE	AXIAL	LATERAL	ROTATIONAL	AXIAL	SHEAR	MOMENT
0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.000D+00	0.0	0.0	0.0	0.0	0.0	0.0
1.000D+01	0.0	0.0	0.0	0.0	0.0	0.0
1.500D+01	0.0	0.0	0.0	0.0	0.0	0.0
2.000D+01	0.0	0.0	0.0	0.0	0.0	0.0
2.500D+01	0.0	0.0	0.0	0.0	0.0	0.0
3.000D+01	0.0	0.0	0.0	0.0	0.0	0.0
3.500D+01	0.0	0.0	0.0	0.0	0.0	0.0
4.000D+01	0.0	0.0	0.0	0.0	0.0	0.0
4.500D+01	0.0	0.0	0.0	0.0	0.0	0.0
5.000D+01	0.0	0.0	0.0	0.0	0.0	0.0
5.500D+01	0.0	0.0	0.0	0.0	0.0	0.0
6.000D+01	0.0	0.0	0.0	0.0	0.0	0.0
6.500D+01	0.0	0.0	0.0	0.0	0.0	0.0
7.000D+01	0.0	0.0	0.0	0.0	0.0	0.0
7.500D+01	0.0	0.0	0.0	0.0	0.0	0.0
8.000D+01	0.0	0.0	0.0	0.0	0.0	0.0
8.500D+01	0.0	0.0	0.0	0.0	0.0	0.0
9.000D+01	0.0	0.0	0.0	0.0	0.0	0.0
9.500D+01	0.0	0.0	0.0	0.0	0.0	0.0
1.000D+02	0.0	0.0	0.0	0.0	0.0	0.0



ELEM NUMD	AXIAL FORC	AXIAL STRAIN	BEND MOMENT	CURVATURE	SHEAR FORCE	SHEAR STRAIN
2	0.0	0.0	0.0	0.0	0.0	0.0
3	0.0	0.0	0.0	0.0	0.0	0.0
4	0.0	0.0	0.0	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0	0.0	0.0
6	0.0	0.0	0.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0	0.0	0.0
13	0.0	0.0	0.0	0.0	0.0	0.0
14	0.0	0.0	0.0	0.0	0.0	0.0
15	0.0	0.0	0.0	0.0	0.0	0.0
16	0.0	0.0	0.0	0.0	0.0	0.0
17	0.0	0.0	0.0	0.0	0.0	0.0
18	0.0	0.0	0.0	0.0	0.0	0.0
19	0.0	0.0	0.0	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0	0.0	0.0
21	0.0	0.0	0.0	0.0	0.0	0.0

I-----TRIM

PROB$_1$ (CONTD)   2ND LOAD INCREMENT (DYNAMIC)

TABLE 10 - JOINT EQULIBRIUM ERRORS

JOINT	ERR(X) FORCE	ERR(Y) FORCE	ERR(Z) MOMENT	EFF(V) MOMENT
1	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0

I-----TPIM

PROB$_1$ (CONTD) 2ND LOAD INCREMENT (DYNAMIC)

RESULTS AT END OF TIME STEP = 11 AND TIME = 0.10000

TABLE 8 - JOINT DISPLACEMENTS, REACTIONS AND SHEAR PANEL INTERNAL MOMENTS

JNT	DISP(X)	DISP(Y)	ROT(Z)	ROT(Y)	REACT(X)	REACT(Y)	REACT(Z)	REACT(V)	SHP.MOM(Z)	SHP.MOM(Y)
1	0.0	-4.0000000D-19	-4.0000000D-17	-6.3794467D-03	0.0	4.000D+01	4.000D+03	0.0	4.000D+03	-4.000D+03
2	0.0	-9.4605412D-01	-1.0395511D-02	0.0	0.0	0.0	0.0	0.0	0.0	0.0
				TOTAL	0.0	4.000D+01	4.000D+03	0.0		

PROB 1 (CONTD) 2ND LOAD INCREMENT (DYNAMIC)

I-----TRIM

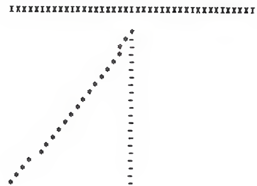
TABLE 9 - MEMBER RESULTS

MEMBER NUMBER 1 TIME STEP 11 TIME 0.100000

MEMBER LENGTH 100.000 NUMBER OF ELEM 20 ELMNT LNGTH 5.0000

MEMBER NUMBER 1 STIFF TYPE 1 LOAD TYPE 0
LENGTH = 0.100D+03 ALPHA = 0.100D+01 BETA = 0.0
GOES FROM JOINT 1 TO JOINT 2
OUTPUT DISTANCES ARE FROM JOINT 1 ALONG THE MEMBER AXIS
ALL OUTPUT FORCES AND DISPLACEMENTS ARE WITH RESPECT TO THE MEMBER AXES

	DISPLACEMENTS			FORCES		
DISTANCE	AXIAL	LATERAL	ROTATIONAL	AXIAL	SHEAR	MOMENT
0.0	0.0	-4.000D-19	-6.379D-03	0.0	4.000D+01	-4.000D+03
5.000D+00	0.0	-3.490D-02	-6.771D-03	0.0	4.000D+01	-3.800D+03
1.000D+01	0.0	-7.171D-02	-7.142D-03	0.0	4.000D+01	-3.600D+03
1.500D+01	0.0	-1.103D-01	-7.494D-03	0.0	4.000D+01	-3.400D+03
2.000D+01	0.0	-1.507D-01	-7.825D-03	0.0	4.000D+01	-3.200D+03
2.500D+01	0.0	-1.926D-01	-8.136D-03	0.0	4.000D+01	-3.000D+03
3.000D+01	0.0	-2.360D-01	-8.428D-03	0.0	4.000D+01	-2.800D+03
3.500D+01	0.0	-2.809D-01	-8.699D-03	0.0	4.000D+01	-2.600D+03
4.000D+01	0.0	-3.270D-01	-8.950D-03	0.0	4.000D+01	-2.400D+03
4.500D+01	0.0	-3.744D-01	-9.181D-03	0.0	4.000D+01	-2.200D+03
5.000D+01	0.0	-4.228D-01	-9.391D-03	0.0	4.000D+01	-2.000D+03
5.500D+01	0.0	-4.723D-01	-9.582D-03	0.0	4.000D+01	-1.800D+03
6.000D+01	0.0	-5.227D-01	-9.753D-03	0.0	4.000D+01	-1.600D+03
6.500D+01	0.0	-5.738D-01	-9.904D-03	0.0	4.000D+01	-1.400D+03
7.000D+01	0.0	-6.257D-01	-1.003D-02	0.0	4.000D+01	-1.200D+03
7.500D+01	0.0	-6.782D-01	-1.014D-02	0.0	4.000D+01	-1.000D+03
8.000D+01	0.0	-7.311D-01	-1.023D-02	0.0	4.000D+01	-8.000D+02
8.500D+01	0.0	-7.845D-01	-1.031D-02	0.0	4.000D+01	-6.000D+02
9.000D+01	0.0	-8.382D-01	-1.036D-02	0.0	4.000D+01	-4.000D+02
9.500D+01	0.0	-8.921D-01	-1.039D-02	0.0	4.000D+01	-2.000D+02
1.000D+02	0.0	-9.461D-01	-1.040D-02	0.0	4.000D+01	1.480D-11



ELEM NUMB	AXIAL FORC	AXIAL STRAIN	BEND MOMENT	CURVATURE	SHEAR FORCE	SHEAR STRAIN
2	0.0	0.0	-3.900D+03	-7.831D-05	4.000D+01	4.054D-04
3	0.0	0.0	-3.700D+03	-7.430D-05	4.000D+01	4.054D-04
4	0.0	0.0	-3.500D+03	-7.028D-05	4.000D+01	4.054D-04
5	0.0	0.0	-3.300D+03	-6.627D-05	4.000D+01	4.054D-04
6	0.0	0.0	-3.100D+03	-6.225D-05	4.000D+01	4.054D-04
7	0.0	0.0	-2.900D+03	-5.823D-05	4.000D+01	4.054D-04
8	0.0	0.0	-2.700D+03	-5.422D-05	4.000D+01	4.054D-04
9	0.0	0.0	-2.500D+03	-5.020D-05	4.000D+01	4.054D-04
10	0.0	0.0	-2.300D+03	-4.618D-05	4.000D+01	4.054D-04
11	0.0	0.0	-2.100D+03	-4.217D-05	4.000D+01	4.054D-04
12	0.0	0.0	-1.900D+03	-3.815D-05	4.000D+01	4.054D-04
13	0.0	0.0	-1.700D+03	-3.414D-05	4.000D+01	4.054D-04
14	0.0	0.0	-1.500D+03	-3.012D-05	4.000D+01	4.054D-04
15	0.0	0.0	-1.300D+03	-2.610D-05	4.000D+01	4.054D-04
16	0.0	0.0	-1.100D+03	-2.209D-05	4.000D+01	4.054D-04
17	0.0	0.0	-9.000D+02	-1.807D-05	4.000D+01	4.054D-04
18	0.0	0.0	-7.000D+02	-1.406D-05	4.000D+01	4.054D-04
19	0.0	0.0	-5.000D+02	-1.004D-05	4.000D+01	4.054D-04
20	0.0	0.0	-3.000D+02	-6.024D-06	4.000D+01	4.054D-04
21	0.0	0.0	-1.000D+02	-2.008D-06	4.000D+01	4.054D-04

I-----TRIM

PROB 1 (CONTD) 2ND LOAD INCREMENT (DYNAMIC)

TABLE 10 - JOINT EQULIBRIUM ERRORS

JOINT	ERR(X) FORCE	ERR(Y) FORCE	ERR(Z) MOMENT	ERR(V) MOMENT
1	0.0	-6.1461947D-13	2.2737368D-13	-5.6274985D-11
2	0.0	4.9382720D-13	-1.4800605D-11	0.0

PROB 1 (CONTD) 2ND LOAD INCREMENT (DYNAMIC) I-----TRIM

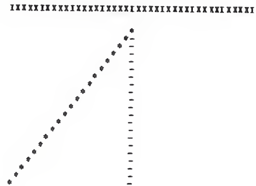
TABLE 9 - MEMBER RESULTS

MEMBER NUMBER 1 TIME STEP 21 TIME 0.200000

MEMBER LENGTH 100.000 NUMBER OF ELEM 20 ELMNT LNGTH 5.0000

MEMBER NUMBER 1 STIFF TYPE 1 LOAD TYPE 0
LENGTH = 0.100D+03 ALPHA = 0.100D+01 BETA = 0.0
GOES FROM JOINT 1 TO JOINT 2
OUTPUT DISTANCES ARE FROM JOINT 1 ALONG THE MEMBER AXIS
ALL OUTPUT FORCES AND DISPLACEMENTS ARE WITH RESPECT TO THE MEMBER AXES

	DISPLACEMENTS			FORCES		
DISTANCE	AXIAL	LATERAL	ROTATIONAL	AXIAL	SHEAR	MOMENT
0.0	0.0	6.929D-34	-3.887D-03	0.0	1.979D-13	5.851D-13
5.000D+00	0.0	-1.943D-02	-3.887D-03	0.0	1.979D-13	1.620D-12
1.000D+01	0.0	-3.887D-02	-3.887D-03	0.0	1.926D-13	2.713D-12
1.500D+01	0.0	-5.830D-02	-3.887D-03	0.0	1.966D-13	3.486D-12
2.000D+01	0.0	-7.773D-02	-3.887D-03	0.0	7.355D-14	4.380D-12
2.500D+01	0.0	-9.717D-02	-3.887D-03	0.0	1.003D-13	4.192D-12
3.000D+01	0.0	-1.166D-01	-3.887D-03	0.0	1.458D-13	4.874D-12
3.500D+01	0.0	-1.360D-01	-3.887D-03	0.0	5.349D-14	4.266D-12
4.000D+01	0.0	-1.555D-01	-3.887D-03	0.0	9.762D-14	4.533D-12
4.500D+01	0.0	-1.749D-01	-3.887D-03	0.0	1.417D-13	4.266D-12
5.000D+01	0.0	-1.943D-01	-3.887D-03	0.0	1.819D-13	3.733D-12
5.500D+01	0.0	-2.138D-01	-3.887D-03	0.0	8.291D-14	4.614D-12
6.000D+01	0.0	-2.332D-01	-3.887D-03	0.0	1.270D-13	4.185D-12
6.500D+01	0.0	-2.526D-01	-3.887D-03	0.0	1.698D-13	4.347D-12
7.000D+01	0.0	-2.721D-01	-3.887D-03	0.0	6.954D-14	3.733D-12
7.500D+01	0.0	-2.915D-01	-3.887D-03	0.0	1.003D-13	2.400D-12
8.000D+01	0.0	-3.109D-01	-3.887D-03	0.0	1.177D-13	1.066D-12
8.500D+01	0.0	-3.304D-01	-3.887D-03	0.0	1.270D-13	7.999D-13
9.000D+01	0.0	-3.498D-01	-3.887D-03	0.0	1.351D-13	7.999D-13
9.500D+01	0.0	-3.692D-01	-3.887D-03	0.0	1.431D-13	7.999D-13
1.000D+02	0.0	-3.887D-01	-3.887D-03	0.0	1.471D-13	9.077D-13



ELEM NUMB	AXIAL FORC	AXIAL STRAIN	BEND MOMENT	CURVATURE	SHEAR FORCE	SHEAR STRAIN
2	0.0	0.0	1.080D-12	2.168D-20	1.979D-13	2.006D-18
3	0.0	0.0	2.160D-12	4.337D-20	1.979D-13	2.006D-18
4	0.0	0.0	3.240D-12	6.505D-20	1.872D-13	1.897D-18
5	0.0	0.0	3.780D-12	7.589D-20	2.059D-13	2.087D-18
6	0.0	0.0	4.319D-12	8.674D-20	-5.884D-14	-5.963D-19
7	0.0	0.0	4.859D-12	9.758D-20	2.594D-13	2.629D-18
8	0.0	0.0	4.319D-12	8.674D-20	3.209D-14	3.253D-19
9	0.0	0.0	4.319D-12	8.674D-20	7.488D-14	7.589D-19
10	0.0	0.0	4.859D-12	9.758D-20	1.204D-13	1.220D-18
11	0.0	0.0	3.780D-12	7.589D-20	1.631D-13	1.653D-18
12	0.0	0.0	3.780D-12	7.589D-20	2.006D-13	2.033D-18
13	0.0	0.0	4.859D-12	9.758D-20	-3.477D-14	-3.524D-19
14	0.0	0.0	4.319D-12	8.674D-20	2.888D-13	2.927D-18
15	0.0	0.0	3.780D-12	7.509D-20	5.081D-14	5.150D-19
16	0.0	0.0	3.780D-12	7.589D-20	8.826D-14	8.945D-19
17	0.0	0.0	1.080D-12	2.168D-20	1.123D-13	1.138D-18
18	0.0	0.0	1.080D-12	2.168D-20	1.230D-13	1.247D-18
19	0.0	0.0	5.399D-13	1.084D-20	1.310D-13	1.328D-18
20	0.0	0.0	1.080D-12	2.168D-20	1.391D-13	1.409D-18
21	0.0	0.0	5.399D-13	1.084D-20	1.471D-13	1.491D-18

I-----TRIM

PROB$_1$ (CONTD)   2ND LOAD INCREMENT (DYNAMIC)

RESULTS AT END OF TIME STEP = 21 AND TIME = 0.20000

TABLE 8 - JOINT DISPLACEMENTS, REACTIONS AND SHEAR PANEL INTERNAL MOMENTS

JNT	DISP(X)	DISP(Y)	ROT(Z)	ROT(V)	REACT(X)	REACT(Y)	REACT(Z)	REACT(V)	SHR.MOM(Z)	SHR.MOM(V)
1	0.0	-1.80104540D-33	1.42518820D-32	-3.88665310D-03	0.0	1.801D-13	-1.425D-12	0.0	-9.295D-13	9.295D-13
2	0.0	-3.80665310D-01	-3.88665310D-03	0.0	0.0	0.0	0.0	0.0	0.0	0.0
				TOTAL	0.0	1.801D-13	-1.425D-12	0.0		

I-----TRIM

PROB 1 (CONTD) 2ND LOAD INCREMENT (DYNAMIC)

TABLE 10 - JOINT EQULIBRIUM ERRORS

JOINT	ERR(X) FORCE	ERR(Y) FORCE	ERR(Z) MOMENT	ERR(V) MOMENT
1	0.0	-1.7805180D-14	-4.9569168D-13	-3.4440542D-13
2	0.0	1.0090979D-13	-9.0767034D-13	0.0

I-----TRIM

$PROB_1$ (CONTD) 2ND LOAD INCREMENT (DYNAMIC)

RESULTS AT END OF TIME STEP = 31 AND TIME = 0.30000

TABLE 8 - JOINT DISPLACEMENTS, REACTIONS AND SHEAR PANEL INTERNAL MOMENTS

JNT	DISP(X)	DISP(Y)	ROT(Z)	ROT(V)	REACT(X)	REACT(Y)	REACT(Z)	REACT(V)	SHR.MOM(Z)	SHR.MOM(V)
1	0.0	4.0000000D-19	4.0000000D-17	6.3794467D-03	0.0	-4.000D+01	-4.000D+03	0.0	-4.000D+03	4.000D+03
2	0.0	9.4605412D-01	1.0395511D-02	0.0	0.0	0.0	0.0	0.0	0.0	0.0
				TOTAL	0.0	-4.000D+01	-4.000D+03	0.0		

I-----TRIM

PROB 1 (CONTD) 2ND LOAD INCREMENT (DYNAMIC)

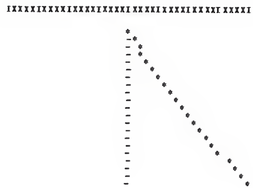
TABLE 9 - MEMBER RESULTS

MEMBER NUMBER 1 TIME STEP 31 TIME 0.300D00

MEMBER LENGTH 100.000 NUMBER OF ELEM 20 ELMNT LNGTH 5.0000

MEMBER NUMBER 1 STIFF TYPE 1 LOAD TYPE 0
LENGTH = 0.100D+03 ALPHA = 0.100D+01 BETA = 0.0
GOES FROM JOINT 1 TO JOINT 2
OUTPUT DISTANCES ARE FROM JOINT 1 ALONG THE MEMBER AXIS
ALL OUTPUT FORCES AND DISPLACEMENTS ARE WITH RESPECT TO THE MEMBER AXES

	DISPLACEMENTS			FORCES		
DISTANCE	AXIAL	LATERAL	ROTATIONAL	AXIAL	SHEAR	MOMENT
0.0	0.0	4.000D-19	6.379D-03	0.0	-4.000D+01	4.000D+03
5.000D+00	0.0	3.490D-02	6.771D-03	0.0	-4.000D+01	3.800D+03
1.000D+01	0.0	7.171D-02	7.142D-03	0.0	-4.000D+01	3.600D+03
1.500D+01	0.0	1.103D-01	7.494D-03	0.0	-4.000D+01	3.400D+03
2.000D+01	0.0	1.507D-01	7.825D-03	0.0	-4.000D+01	3.200D+03
2.500D+01	0.0	1.926D-01	8.136D-03	0.0	-4.000D+01	3.000D+03
3.000D+01	0.0	2.360D-01	8.428D-03	0.0	-4.000D+01	2.800D+03
3.500D+01	0.0	2.809D-01	8.699D-03	0.0	-4.000D+01	2.600D+03
4.000D+01	0.0	3.270D-01	8.950D-03	0.0	-4.000D+01	2.400D+03
4.500D+01	0.0	3.744D-01	9.181D-03	0.0	-4.000D+01	2.200D+03
5.000D+01	0.0	4.228D-01	9.391D-03	0.0	-4.000D+01	2.000D+03
5.500D+01	0.0	4.723D-01	9.582D-03	0.0	-4.000D+01	1.800D+03
6.000D+01	0.0	5.227D-01	9.753D-03	0.0	-4.000D+01	1.600D+03
6.500D+01	0.0	5.738D-01	9.904D-03	0.0	-4.000D+01	1.400D+03
7.000D+01	0.0	6.257D-01	1.003D-02	0.0	-4.000D+01	1.200D+03
7.500D+01	0.0	6.782D-01	1.014D-02	0.0	-4.000D+01	1.000D+03
8.000D+01	0.0	7.311D-01	1.023D-02	0.0	-4.000D+01	8.000D+02
8.500D+01	0.0	7.845D-01	1.031D-02	0.0	-4.000D+01	6.000D+02
9.000D+01	0.0	8.382D-01	1.036D-02	0.0	-4.000D+01	4.000D+02
9.500D+01	0.0	8.921D-01	1.039D-02	0.0	-4.000D+01	2.000D+02
1.000D+02	0.0	9.461D-01	1.040D-02	0.0	-4.000D+01	-1.523D-11



ELEM NUMB	AXIAL FORC	AXIAL STRAIN	BEND MOMENT	CURVATURE	SHEAR FORCE	SHEAR STRAIN
2	0.0	0.0	3.900D+03	7.831D-05	-4.000D+01	-4.054D-04
3	0.0	0.0	3.700D+03	7.430D-05	-4.000D+01	-4.054D-04
4	0.0	0.0	3.500D+03	7.028D-05	-4.000D+01	-4.054D-04
5	0.0	0.0	3.300D+03	6.627D-05	-4.000D+01	-4.054D-04
6	0.0	0.0	3.100D+03	6.225D-05	-4.000D+01	-4.054D-04
7	0.0	0.0	2.900D+03	5.823D-05	-4.000D+01	-4.054D-04
8	0.0	0.0	2.700D+03	5.422D-05	-4.000D+01	-4.054D-04
9	0.0	0.0	2.500D+03	5.020D-05	-4.000D+01	-4.054D-04
10	0.0	0.0	2.300D+03	4.618D-05	-4.000D+01	-4.054D-04
11	0.0	0.0	2.100D+03	4.217D-05	-4.000D+01	-4.054D-04
12	0.0	0.0	1.900D+03	3.815D-05	-4.000D+01	-4.054D-04
13	0.0	0.0	1.700D+03	3.414D-05	-4.000D+01	-4.054D-04
14	0.0	0.0	1.500D+03	3.012D-05	-4.000D+01	-4.054D-04
15	0.0	0.0	1.300D+03	2.610D-05	-4.000D+01	-4.054D-04
16	0.0	0.0	1.100D+03	2.209D-05	-4.000D+01	-4.054D-04
17	0.0	0.0	9.000D+02	1.807D-05	-4.000D+01	-4.054D-04
18	0.0	0.0	7.000D+02	1.406D-05	-4.000D+01	-4.054D-04
19	0.0	0.0	5.000D+02	1.004D-05	-4.000D+01	-4.054D-04
20	0.0	0.0	3.000D+02	6.024D-06	-4.000D+01	-4.054D-04
21	0.0	0.0	1.000D+02	2.008D-06	-4.000D+01	-4.054D-04

I-----TRIM

PROB 1 (CONTD) 2ND LOAD INCREMENT (DYNAMIC)

TABLE 10 - JOINT EQULIBRIUM ERRORS

JOINT	ERR(X) FORCE	ERR(Y) FORCE	ERR(Z) MOMENT	ERR(V) MOMENT
1	0.0	7.0699002D-13	-2.8421709D-13	5.27506 93D-11
2	0.0	-7.1409545D-13	1.5226931D-11	0.0

I-----TRIM

PROB $_1$ (CCNTD)   2ND LOAD INCREMENT (DYNAMIC)

RESULTS AT END OF TIME STEP = 41 AND TIME = 0.40000

TABLE 8 - JOINT DISPLACEMENTS, REACTIONS AND SHEAR PANEL INTERNAL MOMENTS

JNT	DISP(X)	DISP(Y)	ROT(Z)	ROT(V)	REACT(X)	REACT(Y)	REACT(Z)	REACT(V)	SHR.MOM(Z)	SHR.MOM(V)
1	0.0	2.2464167D-33	2.8888949D-32	3.8866531D-03	0.0	-2.246D-13	-2.889D-12	0.0	-3.408D-12	3.408D-12
2	0.0	3.8866531D-01	3.8866531D-03	0.0	0.0	0.0	0.0	0.0	0.0	0.0
				TOTAL	0.0	-2.246D-13	-2.889D-12	0.0		

PROB 1 (CONTD) 2ND LOAD INCREMENT (DYNAMIC)

I-----TRIM

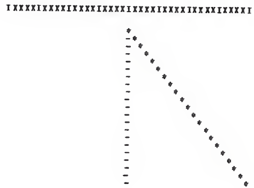
TABLE 9 - MEMBER RESULTS

MEMBER NUMBER 1 TIME STEP 41 TIME D.40000D

MEMBER LENGTH 100.000 NUMBER OF ELEM 20 ELMNT LNGTH 5.D000

MEMBER NUMBER 1 STIFF TYPE 1 LOAD TYPE 0
LENGTH = 0.100D+03 ALPHA = 0.100D+01 BETA = 0.0
GOES FROM JOINT 1 TO JOINT 2
OUTPUT DISTANCES ARE FROM JOINT 1 ALONG THE MEMBER AXIS
ALL OUTPUT FORCES AND DISPLACEMENTS ARE WITH RESPECT TO THE MEMBER AXES

	DISPLACEMENTS			FORCES		
DISTANCE	AXIAL	LATERAL	ROTATIONAL	AXIAL	SHEAR	MOMENT
0.0	0.0	2.023D-33	3.887D-03	0.0	-2.354D-13	3.828D-12
5.000D+00	0.0	1.943D-02	3.887D-03	0.0	-2.140D-13	2.646D-12
1.000D+01	0.0	3.887D-02	3.887D-03	0.0	-2.367D-13	1.460D-12
1.500D+01	0.0	5.830D-02	3.887D-03	0.0	-2.367D-13	1.596D-13
2.000D+01	0.0	7.773D-02	3.887D-03	0.0	-1.725D-13	-8.600D-13
2.50DD+01	0.0	9.717D-02	3.887D-03	0.0	-1.605D-13	-1.600D-12
3.000D+01	0.0	1.166D-01	3.887D-03	0.0	-1.765D-13	-1.600D-12
3.500D+01	0.0	1.360D-01	3.887D-03	0.0	-1.926D-13	-1.600D-12
4.D00D+01	0.0	1.555D-01	3.887D-03	0.0	-7.488D-14	-2.474D-12
4.500D+01	0.0	1.749D-01	3.887D-03	0.0	-9.895D-14	-2.325D-12
5.000D+01	0.0	1.943D-01	3.887D-03	0.0	-1.244D-13	-2.741D-12
5.500D+01	0.0	2.138D-01	3.887D-03	0.0	-1.484D-13	-2.059D-12
6.000D+01	0.0	2.332D-01	3.887D-03	0.0	-1.725D-13	-2.741D-12
6.500D+01	0.0	2.5260-01	3.887D-03	0.0	-1.952D-13	-1.792D-12
7.000D+01	0.0	2.721D-01	3.887D-03	0.0	-2.153D-13	-2.207D-12
7.500D+01	0.0	2.915D-01	3.887D-03	0.0	-9.2270-14	-7.999D-13
8.000D+01	0.0	3.109D-01	3.887D-03	0.0	-9.762D-14	-2.666D-13
8.500D+01	0.0	3.304D-01	3.887D-03	0.0	-1.016D-13	-5.332D-13
9.000D+01	0.0	3.498D-01	3.887D-03	0.0	-1.070D-13	-5.332D-13
9.500D+01	0.0	3.692D-01	3.887D-03	0.0	-2.487D-13	-1.923D-13
1.000D+02	0.0	3.887D-01	3.887D-03	0.0	-3.878D-13	-1.509D-12



ELEM NUMB	AXIAL FORC	AXIAL STRAIN	BEND MOMENT	CURVATURE	SHEAR FCRCE	SHEAR STRAIN
2	D.0	0.0	3.240D-12	6.505D-20	-2.354D-13	-2.385D-18
3	0.0	0.0	2.160D-12	4.337D-20	-1.926D-13	-1.952D-18
4	0.0	0.0	5.399D-13	1.084D-20	-2.808D-13	-2.846D-18
5	0.0	0.0	0.0	0.0	-1.926D-13	-1.952D-18
6	0.0	0.0	-1.620D-12	-3.253D-20	-1.524D-13	-1.545D-18
7	0.0	0.0	-1.620D-12	-3.253D-20	-1.685D-13	-1.708D-18
8	0.0	0.0	-1.620D-12	-3.253D-20	-1.845D-13	-1.870D-18
9	0.0	0.0	-1.62DD-12	-3.253D-20	-2.006D-13	-2.033D-18
10	0.0	0.0	-2.700D-12	-5.421D-20	5.081D-14	5.150D-19
11	0.0	0.0	-2.700D-12	-5.421D-20	-2.487D-13	-2.521D-18
12	0.0	0.0	-2.160D-12	-4.337D-20	0.0	0.0
13	0.0	0.0	-2.70DD-12	-5.421D-20	-2.969D-13	-3.009D-18
14	0.0	0.0	-2.160D-12	-4.337D-20	-4.814D-14	-4.079D-19
15	0.0	0.0	-2.160D-12	-4.337D-20	-3.423D-13	-3.469D-18
16	0.0	0.0	-1.620D-12	-3.253D-20	-8.826D-14	-8.945D-19
17	0.0	0.0	0.0	0.0	-9.628D-14	-9.758D-19
18	0.0	0.0	-5.399D-13	-1.084D-20	-9.895D-14	-1.003D-18
19	0.0	D.0	-5.399D-13	-1.084D-20	-1.043D-13	-1.057D-18
20	D.0	0.0	-5.399D-13	-1.084D-20	-1.097D-13	-1.111D-18
21	0.0	0.0	-5.399D-13	-1.084D-20	-3.878D-13	-3.93DD-18

I-----TRIM

PROB$_1$ (CONTD)   2ND LOAD INCREMENT (DYNAMIC)

TABLE 10 - JOINT EQULIBRIUM ERRORS

JOINT	ERR(X) FORCE	ERR(Y) FORCE	ERR(Z) MOMENT	ERR(V) MOMENT
1	0.0	1.0710430D-14	5.1925884D-13	4.1982259D-13
2	0.0	-2.9897824D-13	1.5094229D-12	0.0

MEMBER NUMBER 1 MEMBER RESPONSES IN THE DIRECTION CF ORIGINAL GECMETRY - RECORDED HYSTERSIS

---- AT THE LEFT END ---

TIME STEP	TIME	AX.FORCE	AX.DISPL	MOMENT	ROTATION	SH.FORCE	LAT.DISPL
1	-2.030D-16	0.0	0.0	0.0	0.0	0.0	0.0
2	1.000D-02	0.0	0.0	-4.000E+02	-2.493E-04	4.000E+00	-4.000E-20
3	2.000D-02	0.0	0.0	-8.000E+02	-4.986E-04	8.000E+00	-8.000E-20
4	3.000D-02	0.0	0.0	-1.200E+03	-7.478E-04	1.200E+01	-1.200E-19
5	4.000D-02	0.0	0.0	-1.600E+03	-9.971E-04	1.600E+01	-1.600E-19
6	5.000D-02	0.0	0.0	-2.000E+03	-1.246E-03	2.000E+01	-2.000E-19
7	6.000D-02	0.0	0.0	-2.400E+03	-1.496E-03	2.400E+01	-2.400E-19
8	7.000D-02	0.0	0.0	-2.800E+03	-1.745E-03	2.800E+01	-2.800E-19
9	8.000D-02	0.0	0.0	-3.200E+03	-3.055E-03	3.200E+01	-3.200E-19
10	9.000D-02	0.0	0.0	-3.600E+03	-4.717E-03	3.600E+01	-3.600E-19
11	1.000D-01	0.0	0.0	-4.000E+03	-6.379E-03	4.000E+01	-4.000E-19
12	1.100D-01	0.0	0.0	-3.600E+03	-6.130E-03	3.600E+01	-3.600E-19
13	1.200D-01	0.0	0.0	-3.200E+03	-5.881E-03	3.200E+01	-3.200E-19
14	1.300D-01	0.0	0.0	-2.800E+03	-5.632E-03	2.800E+01	-2.800E-19
15	1.400D-01	0.0	0.0	-2.400E+03	-5.382E-03	2.400E+01	-2.400E-19
16	1.500D-01	0.0	0.0	-2.000E+03	-5.133E-03	2.000E+01	-2.000E-19
17	1.600D-01	0.0	0.0	-1.600E+03	-4.884E-03	1.600E+01	-1.600E-19
18	1.700D-01	0.0	0.0	-1.200E+03	-4.634E-03	1.200E+01	-1.200E-19
19	1.800D-01	0.0	0.0	-8.000E+02	-4.385E-03	8.000E+00	-8.000E-20
20	1.900D-01	0.0	0.0	-4.000E+02	-4.136E-03	4.000E+00	-4.000E-20
21	2.000D-01	0.0	0.0	5.851E-13	-3.887E-03	1.979E-13	6.929E-34
22	2.100D-01	0.0	0.0	4.000E+02	-3.637E-03	-4.000E+00	4.000E-20
23	2.200D-01	0.0	0.0	8.000E+02	-3.388E-03	-8.000E+00	8.000E-20
24	2.300D-01	0.0	0.0	1.200E+03	-3.139E-03	-1.200E+01	1.200E-19
25	2.400D-01	0.0	0.0	1.600E+03	-2.890E-03	-1.600E+01	1.600E-19
26	2.500D-01	0.0	0.0	2.000E+03	-1.931E-03	-2.000E+01	2.000E-19
27	2.600D-01	0.0	0.0	2.400E+03	-2.687E-04	-2.400E+01	2.400E-19
28	2.700D-01	0.0	0.0	2.800E+03	1.393E-03	-2.800E+01	2.800E-19
29	2.800D-01	0.0	0.0	3.200E+03	3.055E-03	-3.200E+01	3.200E-19
30	2.900D-01	0.0	0.0	3.600E+03	4.717E-03	-3.600E+01	3.600E-19
31	3.000D-01	0.0	0.0	4.000E+03	6.379E-03	-4.000E+01	4.000E-19
32	3.100D-01	0.0	0.0	3.600E+03	6.130E-03	-3.600E+01	3.600E-19
33	3.200D-01	0.0	0.0	3.200E+03	5.881E-03	-3.200E+01	3.200E-19
34	3.300D-01	0.0	0.0	2.800E+03	5.632E-03	-2.800E+01	2.800E-19
35	3.400D-01	0.0	0.0	2.400E+03	5.382E-03	-2.400E+01	2.400E-19
36	3.500D-01	0.0	0.0	2.000E+03	5.133E-03	-2.000E+01	2.000E-19
37	3.600D-01	0.0	0.0	1.600E+03	4.884E-03	-1.600E+01	1.600E-19
38	3.700D-01	0.0	0.0	1.200E+03	4.634E-03	-1.200E+01	1.200E-19
39	3.800D-01	0.0	0.0	8.000E+02	4.385E-03	-8.000E+00	8.000E-20
40	3.900D-01	0.0	0.0	4.000E+02	4.136E-03	-4.000E+00	4.000E-20
41	4.000D-01	0.0	0.0	3.828E-12	3.887E-03	-2.354E-13	2.023E-33

MEMBER NUMBER 1 MEMBER RESPONSES IN THE DIRECTION OF ORIGINAL GEOMETRY - RECORDED HYSTERSIS

---- AT THE RIGHT END ---

TIME STEP	TIME	AX.FORCE	AX.DISPL	MOMENT	ROTATION	SH.FORCE	LAT.DISPL
1	-2.030D-16	0.0	0.0	0.0	0.0	0.0	0.0
2	1.000D-02	0.0	0.0	-7.809E-13	-6.509E-04	4.000E+00	-5.574E-02
3	2.000D-02	0.0	0.0	3.013E-12	-1.302E-03	8.000E+00	-1.115E-01
4	3.000D-02	0.0	0.0	4.579E-12	-1.953E-03	1.200E+01	-1.672E-01
5	4.000D-02	0.0	0.0	5.940E-12	-2.604E-03	1.600E+01	-2.230E-01
6	5.000D-02	0.0	0.0	8.043E-12	-3.254E-03	2.000E+01	-2.707E-01
7	6.000D-02	0.0	0.0	9.717E-12	-3.905E-03	2.400E+01	-3.344E-01
8	7.000D-02	0.0	0.0	7.230E-12	-4.556E-03	2.800E+01	-3.902E-01
9	8.000D-02	0.0	0.0	2.277E-12	-6.260E-03	3.200E+01	-5.520E-01
10	9.000D-02	0.0	0.0	1.761E-11	-8.332E-03	3.600E+01	-7.490E-01
11	1.000D-01	0.0	0.0	1.480E-11	-1.040E-02	4.000E+01	-9.461E-01
12	1.100D-01	0.0	0.0	1.868E-11	-9.745E-03	3.600E+01	-8.903E-01
13	1.200D-01	0.0	0.0	1.210E-11	-9.094E-03	3.200E+01	-8.346E-01
14	1.300D-01	0.0	0.0	7.230E-12	-8.443E-03	2.800E+01	-7.788E-01
15	1.400D-01	0.0	0.0	8.971E-12	-7.792E-03	2.400E+01	-7.231E-01
16	1.500D-01	0.0	0.0	3.240E-12	-7.141E-03	2.000E+01	-6.674E-01
17	1.600D-01	0.0	0.0	5.830E-12	-6.490E-03	1.600E+01	-6.116E-01
18	1.700D-01	0.0	0.0	3.268E-13	-5.839E-03	1.200E+01	-5.559E-01
19	1.800D-01	0.0	0.0	3.347E-12	-5.188E-03	8.000E+00	-5.001E-01
20	1.900D-01	0.0	0.0	-2.807E-12	-4.538E-03	4.000E+00	-4.444E-01
21	2.000D-01	0.0	0.0	9.077E-13	-3.887E-03	1.471E-13	-3.887E-01
22	2.100D-01	0.0	0.0	-1.820E-12	-3.236E-03	-4.000E+00	-3.329E-01
23	2.200D-01	0.0	0.0	-2.490E-12	-2.585E-03	-8.000E+00	-2.772E-01
24	2.300D-01	0.0	0.0	-3.990E-12	-1.934E-03	-1.200E+01	-2.214E-01
25	2.400D-01	0.0	0.0	-5.990E-12	-1.283E-03	-1.600E+01	-1.657E-01
26	2.500D-01	0.0	0.0	1.950E-12	7.728E-05	-2.000E+01	-3.902E-02
27	2.600D-01	0.0	0.0	-8.750E-12	2.141E-03	-2.400E+01	1.580E-01
28	2.700D-01	0.0	0.0	-5.940E-12	4.205E-03	-2.800E+01	3.550E-01
29	2.800D-01	0.0	0.0	-1.210E-11	6.268E-03	-3.200E+01	5.520E-01
30	2.900D-01	0.0	0.0	-1.782E-11	8.332E-03	-3.600E+01	7.490E-01
31	3.000D-01	0.0	0.0	-1.523E-11	1.040E-02	-4.000E+01	9.461E-01
32	3.100D-01	0.0	0.0	-1.933E-11	9.745E-03	-3.600E+01	8.903E-01
33	3.200D-01	0.0	0.0	-1.189E-11	9.094E-03	-3.200E+01	8.346E-01
34	3.300D-01	0.0	0.0	-6.590E-12	8.443E-03	-2.800E+01	7.788E-01
35	3.400D-01	0.0	0.0	-1.004E-11	7.792E-03	-2.400E+01	7.231E-01
36	3.500D-01	0.0	0.0	-3.240E-12	7.141E-03	-2.000E+01	6.674E-01
37	3.600D-01	0.0	0.0	-6.043E-12	6.490E-03	-1.600E+01	6.116E-01
38	3.700D-01	0.0	0.0	-1.396E-12	5.839E-03	-1.200E+01	5.559E-01
39	3.800D-01	0.0	0.0	-3.133E-12	5.188E-03	-8.000E+00	5.001E-01
40	3.900D-01	0.0	0.0	3.021E-12	4.538E-03	-4.000E+00	4.444E-01
41	4.000D-01	0.0	0.0	-1.509E-12	3.887E-03	-3.878E-13	3.887E-01

MEMBER NUMBER 1 SECTION RESPONSE IN THE DIRECTION OF DEFORMED GEOMETRY - RECORDED HYSTERSIS

--------- SECTION CLOSEST TO THE -FROM- JOINT

TIME STEP	TIME	AX.FORCE	AX.STRAIN	MOMENT	CURVATURE	SH.FORCE	SH.STRAIN
1	-2.030D-16	0.0	0.0	0.0	0.0	0.0	0.0
2	1.000D-02	0.0	0.0	-3.900E+02	-7.831E-06	4.000E+00	4.054E-05
3	2.000D-02	0.0	0.0	-7.800E+02	-1.566E-05	8.000E+00	8.108E-05
4	3.000D-02	0.0	0.0	-1.170E+03	-2.349E-05	1.200E+01	1.216E-04
5	4.000D-02	0.0	0.0	-1.560E+03	-3.133E-05	1.600E+01	1.622E-04
6	5.000D-02	0.0	0.0	-1.950E+03	-3.916E-05	2.000E+01	2.027E-04
7	6.000D-02	0.0	0.0	-2.340E+03	-4.699E-05	2.400E+01	2.432E-04
8	7.000D-02	0.0	0.0	-2.730E+03	-5.482E-05	2.800E+01	2.838E-04
9	0.000D-02	0.0	0.0	-3.120E+03	-6.265E-05	3.200E+01	3.243E-04
10	9.000D-02	0.0	0.0	-3.510E+03	-7.048E-05	3.600E+01	3.649E-04
11	1.000D-01	0.0	0.0	-3.900E+03	-7.831E-05	4.000E+01	4.054E-04
12	1.100D-01	0.0	0.0	-3.510E+03	-7.048E-05	3.600E+01	3.649E-04
13	1.200D-01	0.0	0.0	-3.120E+03	-6.265E-05	3.200E+01	3.243E-04
14	1.300D-01	0.0	0.0	-2.730E+03	-5.482E-05	2.800E+01	2.838E-04
15	1.400D-01	0.0	0.0	-2.340E+03	-4.699E-05	2.400E+01	2.432E-04
16	1.500D-01	0.0	0.0	-1.950E+03	-3.916E-05	2.000E+01	2.027E-04
17	1.600D-01	0.0	0.0	-1.560E+03	-3.133E-05	1.600E+01	1.622E-04
18	1.700D-01	0.0	0.0	-1.170E+03	-2.349E-05	1.200E+01	1.216E-04
19	1.800D-01	0.0	0.0	-7.800E+02	-1.566E-05	8.000E+00	8.108E-05
20	1.900D-01	0.0	0.0	-3.900E+02	-7.831E-06	4.000E+00	4.054E-05
21	2.000D-01	0.0	0.0	1.080E-12	2.168E-20	1.979E-13	2.006E-18
22	2.100D-01	0.0	0.0	3.900E+02	7.831E-06	-4.000E+00	-4.054E-05
23	2.200D-01	0.0	0.0	7.800E+02	1.566E-05	-8.000E+00	-8.108E-05
24	2.300D-01	0.0	0.0	1.170E+03	2.349E-05	-1.200E+01	-1.216E-04
25	2.400D-01	0.0	0.0	1.560E+03	3.133E-05	-1.600E+01	-1.622E-04
26	2.500D-01	0.0	0.0	1.950E+03	3.916E-05	-2.000E+01	-2.027E-04
27	2.600D-01	0.0	0.0	2.340E+03	4.699E-05	-2.400E+01	-2.432E-04
28	2.700D-01	0.0	0.0	2.730E+03	5.482E-05	-2.800E+01	-2.838E-04
29	2.800D-01	0.0	0.0	3.120E+03	6.265E-05	-3.200E+01	-3.243E-04
30	2.900D-01	0.0	0.0	3.510E+03	7.048E-05	-3.600E+01	-3.649E-04
31	3.000D-01	0.0	0.0	3.900E+03	7.831E-05	-4.000E+01	-4.054E-04
32	3.100D-01	0.0	0.0	3.510E+03	7.048E-05	-3.600E+01	-3.649E-04
33	3.200D-01	0.0	0.0	3.120E+03	6.265E-05	-3.200E+01	-3.243E-04
34	3.300D-01	0.0	0.0	2.730E+03	5.482E-05	-2.800E+01	-2.838E-04
35	3.400D-01	0.0	0.0	2.340E+03	4.699E-05	-2.400E+01	-2.432E-04
36	3.500D-01	0.0	0.0	1.950E+03	3.916E-05	-2.000E+01	-2.027E-04
37	3.600D-01	0.0	0.0	1.560E+03	3.133E-05	-1.600E+01	-1.622E-04
38	3.700D-01	0.0	0.0	1.170E+03	2.349E-05	-1.200E+01	-1.216E-04
39	3.800D-01	0.0	0.0	7.800E+02	1.566E-05	-8.000E+00	-8.108E-05
40	3.900D-01	0.0	0.0	3.900E+02	7.831E-06	-4.000E+00	-4.054E-05
41	4.000D-01	0.0	0.0	3.240E-12	6.505E-20	-2.354E-13	-2.385E-18

MEMBER NUMBER 1 SECTION RESPONSE IN THE DIRECTION OF DEFORMED GEOMETRY - RECORDED HYSTERSIS

--------- SECTION CLOSEST TO THE -TO- JOINT

TIME STEP	TIME	AX.FORCE	AX.STRAIN	MOMENT	CURVATURE	SH.FORCE	SH.STRAIN
1	-2.030D-16	0.0	0.0	0.0	0.0	0.0	0.0
2	1.000D-02	0.0	0.0	-1.000E+01	-2.008E-07	4.000E+00	4.054E-05
3	2.000D-02	0.0	0.0	-2.000E+01	-4.016E-07	8.000E+00	8.108E-05
4	3.000D-02	0.0	0.0	-3.000E+01	-6.024E-07	1.200E+01	1.216E-04
5	4.000D-02	0.0	0.0	-4.000E+01	-8.032E-07	1.600E+01	1.622E-04
6	5.000D-02	0.0	0.0	-5.000E+01	-1.004E-06	2.000E+01	2.027E-04
7	6.000D-02	0.0	0.0	-6.000E+01	-1.205E-06	2.400E+01	2.432E-04
8	7.000D-02	0.0	0.0	-7.000E+01	-1.406E-06	2.800E+01	2.838E-04
9	8.000D-02	0.0	0.0	-8.000E+01	-1.606E-06	3.200E+01	3.243E-04
10	9.000D-02	0.0	0.0	-9.000E+01	-1.807E-06	3.600E+01	3.649E-04
11	1.000D-01	0.0	0.0	-1.000E+02	-2.008E-06	4.000E+01	4.054E-04
12	1.100D-01	0.0	0.0	-9.000E+01	-1.807E-06	3.600E+01	3.649E-04
13	1.200D-01	0.0	0.0	-8.000E+01	-1.606E-06	3.200E+01	3.243E-04
14	1.300D-01	0.0	0.0	-7.000E+01	-1.406E-06	2.800E+01	2.838E-04
15	1.400D-01	0.0	0.0	-6.000E+01	-1.205E-06	2.400E+01	2.432E-04
16	1.500D-01	0.0	0.0	-5.000E+01	-1.004E-06	2.000E+01	2.027E-04
17	1.600D-01	0.0	0.0	-4.000E+01	-8.032E-07	1.600E+01	1.622E-04
18	1.700D-01	0.0	0.0	-3.000E+01	-6.024E-07	1.200E+01	1.216E-04
19	1.800D-01	0.0	0.0	-2.000E+01	-4.016E-07	8.000E+00	8.108E-05
20	1.900D-01	0.0	0.0	-1.000E+01	-2.008E-07	4.000E+00	4.054E-05
21	2.000D-01	0.0	0.0	5.399E-13	1.084E-20	1.471E-13	1.491E-18
22	2.100D-01	0.0	0.0	1.000E+01	2.008E-07	-4.000E+00	-4.054E-05
23	2.200D-01	0.0	0.0	2.000E+01	4.016E-07	-8.000E+00	-8.108E-05
24	2.300D-01	0.0	0.0	3.000E+01	6.024E-07	-1.200E+01	-1.216E-04
25	2.400D-01	0.0	0.0	4.000E+01	8.032E-07	-1.600E+01	-1.622E-04
26	2.500D-01	0.0	0.0	5.000E+01	1.004E-06	-2.000E+01	-2.027E-04
27	2.600D-01	0.0	0.0	6.000E+01	1.205E-06	-2.400E+01	-2.432E-04
28	2.700D-01	0.0	0.0	7.000E+01	1.406E-06	-2.800E+01	-2.838E-04
29	2.800D-01	0.0	0.0	8.000E+01	1.606E-06	-3.200E+01	-3.243E-04
30	2.900D-01	0.0	0.0	9.000E+01	1.807E-06	-3.600E+01	-3.649E-04
31	3.000D-01	0.0	0.0	1.000E+02	2.008E-06	-4.000E+01	-4.054E-04
32	3.100D-01	0.0	0.0	9.000E+01	1.807E-06	-3.600E+01	-3.649E-04
33	3.200D-01	0.0	0.0	8.000E+01	1.606E-06	-3.200E+01	-3.243E-04
34	3.300D-01	0.0	0.0	7.000E+01	1.406E-06	-2.800E+01	-2.838E-04
35	3.400D-01	0.0	0.0	6.000E+01	1.205E-06	-2.400E+01	-2.432E-04
36	3.500D-01	0.0	0.0	5.000E+01	1.004E-06	-2.000E+01	-2.027E-04
37	3.600D-01	0.0	0.0	4.000E+01	8.032E-07	-1.600E+01	-1.622E-04
38	3.700D-01	0.0	0.0	3.000E+01	6.024E-07	-1.200E+01	-1.216E-04
39	3.800D-01	0.0	0.0	2.000E+01	4.016E-07	-8.000E+00	-8.108E-05
40	3.900D-01	0.0	0.0	1.000E+01	2.008E-07	-4.000E+00	-4.054E-05
41	4.000D-01	0.0	0.0	-5.399E-13	-1.084E-20	-3.878E-13	-3.930E-18

```
JOINT DISPLACEMENTS AT TIME =      0.4000                                              I-----TRIM

   0.0              2.2464D-33     2.8889D-32     3.8867D-03
   0.0              3.8867D-01     3.8867D-03     0.0

JCINT VELOCITIES     AT TIME =      0.4000

   0.0             -3.2548D-32     1.1932D-29    -7.1575D-02
   0.0             -7.1575D+00    -7.1575D-02     0.0

JCINT ACCLERATIONS  AT TIME =      0.4000

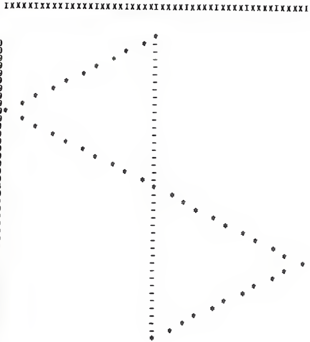
   0.0              1.6220D-26     2.5967D-25    -2.1129D+03
   0.0             -2.1129D+05    -2.1129D+03     0.0
```

```
   JOINT    1
JT  TIME  DISPLACEMENT IXXXXIXXXXIXXXXIXXXXIXXXXIXXXXIXXXXIXXXXIXXXXIXXXXI
          X-DIRECTION


       ALL VALUES ZERO
```

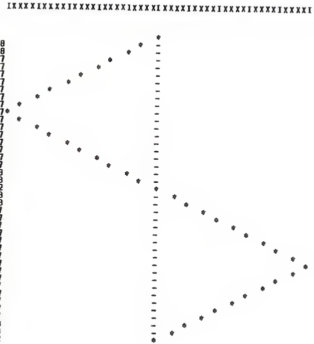
JCINT 1

JT	TIME	DISPLACEMENT Y-DIRECTION
1	-0.00000	0.0
2	0.01000	-4.0000D-20
3	0.02000	-8.0000D-20
4	0.03000	-1.2000D-19
5	0.04000	-1.6000D-19
6	0.05000	-2.0000D-19
7	0.06000	-2.40000-19
8	0.07000	-2.8000D-19
9	0.08000	-3.2000D-19
10	0.09000	-3.6000D-19
11	0.10000	-4.0000D-19
12	0.11000	-3.6000D-19
13	0.12000	-3.2000D-19
14	0.13000	-2.8000D-19
15	0.14000	-2.4000D-19
16	0.15000	-2.0000D-19
17	0.16000	-1.6000D-19
18	0.17000	-1.2000D-19
19	0.18000	-8.00000-20
20	0.19000	-4.0000D-20
21	0.20000	-1.8010D-33
22	0.21000	4.0000D-20
23	0.22000	8.0000D-20
24	0.23000	1.2000D-19
25	0.24000	1.6000D-19
26	0.25000	2.0000D-19
27	0.26000	2.4000D-19
28	0.27000	2.8000D-19
29	0.28000	3.2000D-19
30	0.29000	3.6000D-19
31	0.30000	4.0000D-19
32	0.31000	3.6000D-19
33	0.32000	3.2000D-19
34	0.33000	2.8000D-19
35	0.34000	2.4000D-19
36	0.35000	2.0000D-19
37	0.36000	1.6000D-19
38	0.37000	1.2000D-19
39	0.38000	8.0000D-20
40	0.39000	4.0000D-20
41	0.40000	2.2464D-33



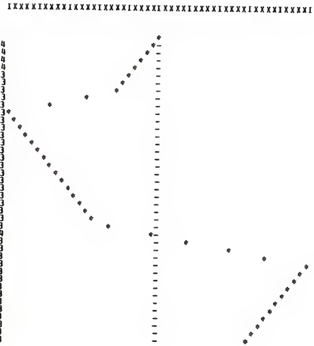
JOINT 1

JT	TIME	ROTATION Z-ROTATION
1	-0.00000	0.0
2	0.01000	-4.0000D-18
3	0.02000	-8.0000D-18
4	0.03000	-1.2000D-17
5	0.04000	-1.6000D-17
6	0.05000	-2.0000D-17
7	0.06000	-2.4000D-17
8	0.07000	-2.8000D-17
9	0.08000	-3.2000D-17
10	0.09000	-3.6000D-17
11	0.10000	-4.0000D-17
12	0.11000	-3.6000D-17
13	0.12000	-3.2000D-17
14	0.13000	-2.8000D-17
15	0.14000	-2.4000D-17
16	0.15000	-2.0000D-17
17	0.16000	-1.6000D-17
18	0.17000	-1.2000D-17
19	0.18000	-8.0000D-18
20	0.19000	-4.0000D-18
21	0.20000	1.4252D-32
22	0.21000	4.0000D-18
23	0.22000	8.0000D-18
24	0.23000	1.2000D-17
25	0.24000	1.6000D-17
26	0.25000	2.0000D-17
27	0.26000	2.4000D-17
28	0.27000	2.8000D-17
29	0.28000	3.2000D-17
30	0.29000	3.6000D-17
31	0.30000	4.0000D-17
32	0.31000	3.6000D-17
33	0.32000	3.2000D-17
34	0.33000	2.8000D-17
35	0.34000	2.4000D-17
36	0.35000	2.0000D-17
37	0.36000	1.6000D-17
38	0.37000	1.2000D-17
39	0.38000	8.0000D-18
40	0.39000	4.0000D-18
41	0.40000	2.8889D-32



JOINT 1

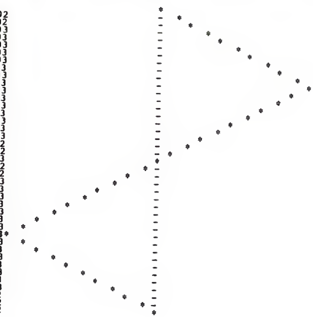
JT	TIME	ROTATION V-ROTATION
1	-0.00000	0.0
2	0.01000	-2.4928D-04
3	0.02000	-4.9856D-04
4	0.03000	-7.4784D-04
5	0.04000	-9.9712D-04
6	0.05000	-1.2464D-03
7	0.06000	-1.4957D-03
8	0.07000	-1.7450D-03
9	0.08000	-3.0554D-03
10	0.09000	-4.7174D-03
11	0.10000	-6.3794D-03
12	0.11000	-6.1302D-03
13	0.12000	-5.8809D-03
14	0.13000	-5.6316D-03
15	0.14000	-5.3823D-03
16	0.15000	-5.1330D-03
17	0.16000	-4.8838D-03
18	0.17000	-4.6345D-03
19	0.18000	-4.3852D-03
20	0.19000	-4.1359D-03
21	0.20000	-3.8867D-03
22	0.21000	-3.6374D-03
23	0.22000	-3.3881D-03
24	0.23000	-3.1388D-03
25	0.24000	-2.8895D-03
26	0.25000	-1.9308D-03
27	0.26000	-2.6871D-04
28	0.27000	1.3933D-03
29	0.28000	3.0554D-03
30	0.29000	4.7174D-03
31	0.30000	6.3794D-03
32	0.31000	6.1302D-03
33	0.32000	5.8809D-03
34	0.33000	5.6316D-03
35	0.34000	5.3823D-03
36	0.35000	5.1330D-03
37	0.36000	4.8838D-03
38	0.37000	4.6345D-03
39	0.38000	4.3852D-03
40	0.39000	4.1359D-03
41	0.40000	3.8867D-03



JOINT 1

JT TIME SH.MOMENT(Z) IXXXXIXXXXIXXXXIXXXXIXXXXIXXXXIXXXXIXXXXIXXXXIXXXXI

JT	TIME	SH.MOMENT(Z)
1	-0.00000	0.0
2	0.01000	4.0000D+02
3	0.02000	8.0000D+02
4	0.03000	1.2000D+03
5	0.04000	1.6000D+03
6	0.05000	2.0000D+03
7	0.06000	2.4000D+03
8	0.07000	2.8000D+03
9	0.080C0	3.2000D+03
10	0.09000	3.6000D+03
11	0.10000	4.0000D+03
12	0.11000	3.6000D+03
13	0.12000	3.2000D+03
14	0.13000	2.8000D+03
15	0.14000	2.4000D+03
16	0.15000	2.0000D+03
17	0.16000	1.6000D+03
18	0.17000	1.2000D+03
19	0.18000	8.0000D+02
20	0.19000	4.0000D+02
21	0.20000	-9.2950D-13
22	0.21000	-4.0000D+02
23	0.22000	-8.0000D+02
24	0.23000	-1.2000D+03
25	0.24000	-1.6000D+03
26	0.25000	-2.0000D+03
27	0.26000	-2.4000D+03
28	0.27000	-2.8000D+03
29	0.28000	-3.2000D+03
30	0.29000	-3.6000D+03
31	0.30000	-4.0000D+03
32	0.31000	-3.6000D+03
33	0.32000	-3.2000D+03
34	0.33000	-2.8000D+03
35	0.34000	-2.4000D+03
36	0.35000	-2.0000D+03
37	0.36000	-1.6000D+03
38	0.37000	-1.2000D+03
39	0.38000	-8.0000D+02
40	0.39000	-4.0000D+02
41	0.40000	-3.4082D-12

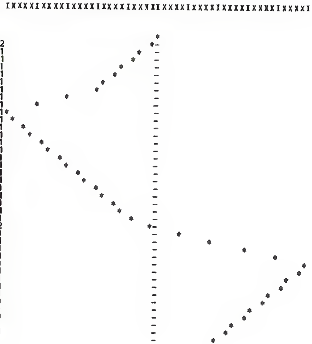


```
   JCINT    2
JT  TIME  DISPLACEMENT IXXXXIXXXXIXXXXIXXXXIXXXXIXXXXIXXXXIXXXXIXXXXIXXXXI
          X-DIRECTION


       ALL VALUES ZERO
```

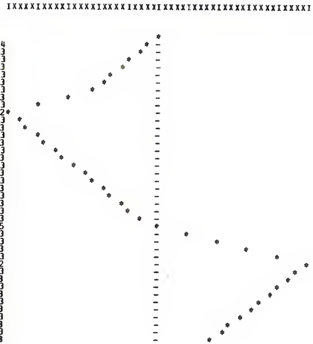
JOINT 2

JT	TIME	DISPLACEMENT Y-DIRECTION
1	-0.00000	0.0
2	0.01000	-5.5739D-02
3	0.02000	-1.1148D-01
4	0.03000	-1.6722D-01
5	0.04000	-2.2296D-01
6	0.05000	-2.7869D-01
7	0.06000	-3.3443D-01
8	0.07000	-3.9017D-01
9	0.08000	-5.5202D-01
10	0.09000	-7.4904D-01
11	0.10000	-9.4605D-01
12	0.11000	-8.9032D-01
13	0.12000	-8.3458D-01
14	0.13000	-7.7884D-01
15	0.14000	-7.2310D-01
16	0.15000	-6.6736D-01
17	0.16000	-6.1162D-01
18	0.17000	-5.5588D-01
19	0.18000	-5.0014D-01
20	0.19000	-4.4440D-01
21	0.20000	-3.8867D-01
22	0.21000	-3.3293D-01
23	0.22000	-2.7719D-01
24	0.23000	-2.2145D-01
25	0.24000	-1.6571D-01
26	0.25000	-3.9021D-02
27	0.26000	1.5799D-01
28	0.27000	3.5501D-01
29	0.28000	5.5202D-01
30	0.29000	7.4904D-01
31	0.30000	9.4605D-01
32	0.31000	8.9032D-01
33	0.32000	8.3458D-01
34	0.33000	7.7884D-01
35	0.34000	7.2310D-01
36	0.35000	6.6736D-01
37	0.36000	6.1162D-01
38	0.37000	5.5588D-01
39	0.38000	5.0014D-01
40	0.39000	4.4440D-01
41	0.40000	3.8867D-01



JOINT 2

JT	TIME	ROTATION Z-ROTATION
1	-0.00000	0.0
2	0.01000	-6.5089D-04
3	0.02000	-1.3018D-03
4	0.03000	-1.9527D-03
5	0.04000	-2.6035D-03
6	0.05000	-3.2544D-03
7	0.06000	-3.9053D-03
8	0.07000	-4.5562D-03
9	0.08000	-6.2682D-03
10	0.09000	-8.3319D-03
11	0.10000	-1.0396D-02
12	0.11000	-9.7446D-03
13	0.12000	-9.0937D-03
14	0.13000	-8.4429D-03
15	0.14000	-7.7920D-03
16	0.15000	-7.1411D-03
17	0.16000	-6.4902D-03
18	0.17000	-5.8393D-03
19	0.18000	-5.1884D-03
20	0.19000	-4.5375D-03
21	0.20000	-3.8867D-03
22	0.21000	-3.2358D-03
23	0.22000	-2.5849D-03
24	0.23000	-1.9340D-03
25	0.24000	-1.2831D-03
26	0.25000	7.7278D-05
27	0.26000	2.1409D-03
28	0.27000	4.2046D-03
29	0.28000	6.2682D-03
30	0.29000	8.3319D-03
31	0.30000	1.0396D-02
32	0.31000	9.7446D-03
33	0.32000	9.0937D-03
34	0.33000	8.4429D-03
35	0.34000	7.7920D-03
36	0.35000	7.1411D-03
37	0.36000	6.4902D-03
38	0.37000	5.8393D-03
39	0.38000	5.1884D-03
40	0.39000	4.5375D-03
41	0.40000	3.8867D-03



```
   JOINT    2
JT  TIME  ROTATION    IXXXXIXXXXIXXXXIXXXXIXXXXIXXXXIXXXXIXXXXIXXXXIXXXXI
          V-ROTATION

       ALL VALUES ZERO
```

```
   JOINT    2
JT  TIME  SH.MOMENT(Z) IXXXXIXXXXIXXXXIXXXXIXXXXIXXXXIXXXXIXXXXIXXXXIXXXXI


        ALL VALUES ZERO
```

APPENDIX I
DIGITIZED VALUES OF EARTHQUAKE MOTIONS EL CENTRO 1940 AND EC400-I

```
EL CENTRO EARTHQUAKE:- NUMBER OF POINTS = 100;
ACCELERATION AXIS MULTIPLIER = 0.0001 TIMES G; TIME AXIS MULTIPLIER = 0.001 SEC.

ACCELERATION                   108    10   159    -1   189     1    59   -12   200  -237    76
  425    94   138   -88  -256  -387  -568  -232  -343  -402  -603  -789  -666  -381  -429   897
-1696  -828  -828  -945  -885-1080-1280  1144  2355  1428  1777-2610-3194  2952  2634-2984
   54  2865  -469  1516  2077  1087  -325  1033  -803   520-1547    65-2060  1927  -937  1708
 -359   365  -736   311-1833   227  -435   216-1972-1762  1460   -47  2572-2045   608-2733
 1779   301  2183   267  1252  1290  1089  -239  1723-1021   141-1949  -242   -50  -275  -573
 -327   216   108   235  -669    14   493   149  -200
TIME                             0    42    97   161   221   263   291   332   374   429   471
  581   623   665   720   750   789   830   872   906   941   963   997  1066  1075  1094  1168
 1315  1384  1412  1440  1481  1509  1537  1628  1703  1800  1855  1924  2007  2215  2270  2320
 2395  2450  2519  2575  2652  2708  2769  2893  2976  3068  3129  3212  3250  3386  3419  3530
 3599  3668  3738  3835  3904  4014  4056  4106  4222  4314  4416  4471  4618  4665  4756  4831
 4970  5039  5108  5199  5233  5302  5330  5343  5454  5510  5606  5690  5773  5800  5809  5869
 5883  5925  5980  6013  6085  6132  6174  6188  6189


EC400-I EARTHQUAKE:- NUMBER OF POINTS = 218;
ACCELERATION AXIS MULTIPLIER = 0.0001 TIMES G; TIME AXIS MULTIPLIER = 0.001 SEC.

ACCELERATION                   112    66  -448   736  -163   341  -118   413  -454   -93   560
 -442   -33   332  -464   420   -70   182  -631   323  -427   423  -743   526  -442   345  -818
  498  -885   520  -774   609  -508   547  -592   793  -541   600  -558   673  -530   790  -743
  776  -799   806  -749   770  -608   866  -600   875  -636   970  -583   758  -577   458  -745
  969  -979   910  -272   105  -750   789  -415   509  -388  -515  -119  -710   455-1234   194
 -484   723  1537  -437  -590-1249  -435  -566  -126  -388  1872  3278  1280  2730   402  1479
-1045-5349-3461-1594-1704  1721  3675   425-3592  3653-1726  1084  1896  -474   645-2385
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-3115   641  -258   467  1018-1592  -492-1721  3157  -243  2745  1320-3618  2048-4096  1439
 1618   280  2543  -594   637    45   507-2082  1497-2694   841-3417   403  -694   -57  -562
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 1038  -920  -243  -511  1636-1068  1145-1955   303   936-1527  1082-1645   502   280   521
 -402  -317   624-1619  1274-1077  1007  1466  -665  1506  -580   890  -580   -74  -951   191
 -858    45    93  2186  -664   -62  -497  -184-2939  1616  -709  1501-2009  -925-1739
TIME                             0   110   169   213   258   309   361   405   442   478   493
  545   574   603   633   699   743   802   817   898   935   994  1030  1097  1126  1207  1229
 1295  1332  1391  1428  1494  1538  1590  1627  1685  1752  1781  1832  1884  1921  1987  2017
 2090  2134  2193  2230  2289  2340  2392  2443  2502  2546  2598  2664  2701  2753  2797  2863
 2900  2966  3010  3062  3121  3143  3194  3231  3305  3341  3459  3503  3547  3621  3658  3717
 3753  3790  3834  3864  3937  3930  4018  4085  4129  4217  4261  4283  4342  4386  4438  4504
 4548  4607  4637  4666  4740  4784  4857  4945  5005  5093  5174  5225  5277  5343  5402  5454
 5520  5579  5638  5696  5763  5807  5873  5939  6006  6108  6190  6248  6322  6366  6425  6491
 6550  6616  6661  6712  6778  6845  6896  6948  7073  7146  7205  7293  7330  7403  7485  7588
 7676  7735  7794  7868  7919  7963  8007  8066  8125  8206  8294  8361  8434  8471  8493  8537

 8604  8670  8707  8773  8832  8920  9008  9052  9126  9170  9207  9251  9295  9347  9391  9465
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Vinayagamoorthy Balachandran was born on October 15, 1952, in Jaffna, Sri Lanka. He entered the University of Sri Lanka, Peradeniya, as the second best student in the nation and earned B.Sc. (Eng.) Honors degree in civil engineering in March, 1975. He was awarded Quickshaws Scholarship—1973 and E.O.E. Pereira Scholarship—1974 for the best performance made in second and third year examinations. Upon graduation he worked as an assistant lecturer in the same university.

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I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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